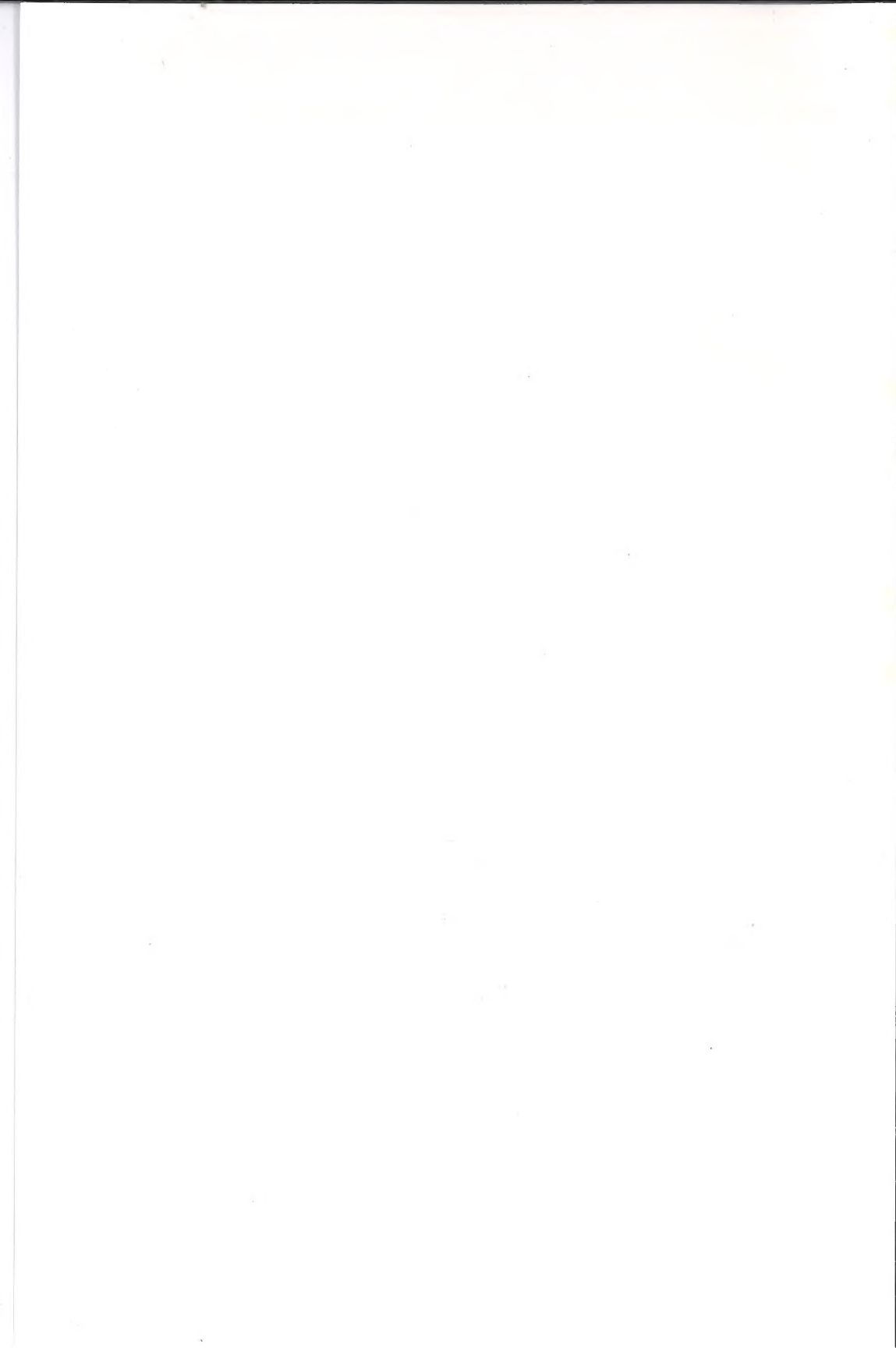University of Wisconsin-Stout

Journal of Student
Research

University of Wisconsin-Stout

Journal of Student Research

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Aims and Scope

Through the initiative of Chancellor Charles Sorensen, Provost Robert Sedlak and Associate Vice Chancellor Julie Furst-Bowe, the Journal of Student Research was created as a means for students, both undergraduate and graduate, to showcase their works of research in a professionally refereed academic format. The Journal promotes student research in all of the academic programs offered through the University of Wisconsin-Stout.

As the University of Wisconsin-Stout continually integrates research into the curriculum, the Journal of Student Research is one of the foremost examples of the commitment to institutional infrastructure that will support the continued development of research. As Stout further addresses research in teaching and curriculum, the Journal will serve as an academic vehicle for students to express themselves and their individual works of research. The University of Wisconsin-Stout has long been considered a pioneer in the field of applied education and the Journal serves as a product of this pioneering attitude. As an example to this pioneering attitude, the Journal of Student Research is the only academic Journal in the University of Wisconsin-System to be published both electronically and in print format on a yearly basis.

The new millennium is well under way and as Stout constantly moves towards its goal of becoming a fully integrated electronic campus, the Journal of Student Research plans to continually grow in stature and complexity and provide a format that will support more digitally interactive research. This proactive approach to technology as well as the feeling of accomplishment supplied by student contributors, will help the Journal of Student Research become a leader in student academic publications and will facilitate the continued quality education opportunities that the University of Wisconsin-Stout has to offer.

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Sister Celine's Methods, Theorems, and Demonstrations

Scott Brown, Casey Wohlers, Marci Denil, Tanya Stephens, Deanne Pieper,
Mathematics Statistics and Computer Sciences

Sister Mary Celine Fasenmyer made a name for herself with her 1945 doctoral thesis (in Mathematics) on a general expression for hypergeometric functions with significant applications to computerized proofs. Our investigation begins with a refresher of hypergeometric functions, since they are a very important part of Sister Celine's research. Sister Celine is famous for what is known as Sister Celine's Method, which involves linear algebra and hypergeometric functions. Using this method and computer programs, such as Maple, has simplified some very complex mathematical proofs. Sister Celine was a mathematician ahead of her time, whose research will be highly valued and admired for years to come.

Keywords: Hypergeometric Functions, Sister Mary Celine, Maple, Algebra, Polynomial

Family Impact Analysis of Wisconsin Statutes Addressing Parental Responsibility for Juvenile Misbehavior

Laura Pollesch, Human Development Family Living Community Educational Services Human Development and Family Studies Program

One of the more fundamental premises of family functioning in our society is the right and responsibility of parents to control and direct the upbringing of their children. Not only do parents have legally protected rights and authority to care for their children, they also have the moral obligation and responsibility to do so. All states have parental liability statutes that hold parents responsible for when their minor child commits a crime. These parental responsibility laws vary in specificity and intent but all attempt to influence and regulate parenting behaviors with the goal of reducing juvenile misbehavior. Are they effective? What consequences do they have for families? Family Impact Analysis is a research method that allows family scholars to assess the intended and unintended consequences of public policies on families. This study applies the principles of Family Impact Analysis to evaluate the consequences of Wisconsin parental responsibility statutes on family behavior and functioning.

Keywords: Parents Responsibility, Juvenile Delinquency, Wisconsin Statutes, Family Analysis

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A Study on the Mineral Contents in the Seed Coat in Relationship with Canning Quality in Different Dark Red Kidney Beans (PHASEOLUS VULGARIS L.)

Xiaojun Wu, Food Science and Nutrition

Three different dark red kidney bean (Phaseolus vulgaris L.) cultivars (cv. 85, cv.453 and cv. Nickols) grown in Wisconsin were studied in this research. Correlations of the mineral contents in the seed coat and seed coat splits in the canned beans were investigated. In the canned product, highly significant differences (p≤0.01) in percentage of split seed coat were found among the three cultivars studied. Canned cv. 85 had significantly fewer seed coat splits than the other two cultivars. Significant negative correlations were found between the percentage of seed coat splits and minerals, such as sodium (r = -0.89, p≤ 0.01), calcium (r = -0.74, p≤0.01) and iron content (r = -0.79, p≤0.05) in the seed coat. A positive correlation was found between sodium content and calcium content (r = 0.69, p≤0.05) in the seed coat. Increased calcium content in the seed coat was accompanied with increased sodium content. This research suggested that several factors of the seed coat, including sodium, calcium, and iron content, may play important roles in the integrity of the seed coat during thermal processing.

Keywords: Kidney Beans, Mineral Content, Seed Coat Splitting, Kidney Bean Canning, Processing Effects

Creating Texture Screens

Briana L. Rutherford, Media/Photography

Texture screens have been a part of photography and darkroom processing for around 60 years. The process itself can be rather simple, however the possibilities are tremendous. This paper, gives a brief history and the comprehensive theories behind texture screens. Also included are research and experiments with the creation of six tests, and two resultant texture screens. The research continues using the subsequent screens on a sample photograph, creating a thorough documentation of the many possibilities available. This paper will show, step by step, that quite interesting effects in photography can be achieved at a very low cost by producing one's own texture screens using a simple darkroom setup.

Keywords: Texture Screen, William Herbert Mortenson, Photograph, Black and White, Darkroom, Contrast, Detail

Asymptotic Techniques in Enzyme Kinetics

Ryan Borek, Eric Wolf, Dallas Hamann, Carrie Ruda, Carissa Staples,
Applied Mathematics

Abstract
Asymptotic techniques in enzyme kinetics is a very large and in-depth subject. This paper will introduce the reader to a couple of the asymptotic techniques in enzyme kinetics. In order to introduce the reader to these techniques, the paper also introduces elementary ideas needed before investigating the asymptotic techniques. These elementary ideas include: compartmental diagrams, the law of mass action, and enzyme basics. Once an understanding of these elementary ideas is achieved, the paper discusses two approximation techniques used in approximating the rate of an enzyme reaction. These approximation techniques are the Equilibrium Approximation and the Quasi-Steady-State Approximation. This paper finds that these techniques are similar but still have some differences when approximating the rate of enzyme reactions.

Keywords: Enzyme, Biochemical Modeling, Compartmental Diagrams, Inhibition, Law of Mass Action, Asymptotic, Equilibrium Approximation, Physiological

Perceptions of the Alcohol and Other Drug Environment at UW-Stout

G. Scott Davis, Brad Griesbach, Richard Koopman Jr., Jared M. Samuels,
Applied Psychology

This study gathered information about the perceptions of the alcohol and other drug environment at the University of Wisconsin-Stout. Through a revision of a May 2000 survey conducted by the Chancellor's Coalition Addressing Problem Drinking (CCAPD), 217 University faculty/staff and 1,463 students were surveyed. Student and faculty/staff participants were chosen from the Outlook Informational Directory for the UW-Stout campus and surveyed using an on-line survey consisting of qualitative questions. Results indicated that while both students and faculty/staff perceived an alcohol and other drug problem at UW-Stout, the cause of the problem is perceived differently. University employees most frequently identified the community and UW-Stout as the causative factor for these problems and a need for more educational information. Students identified individual factors and a need for more enforcement by both the University and the community as the number one action to reduce the alcohol and other drug problem. The findings of the study indicate that these two groups believe there is an above average alcohol and other drug problem on campus and more intervention practices are needed. The research ends with suggestions forwarded by the authors regarding possible implications of this study.

Keywords: Alcohol Abuse, Drug Abuse, Problem Drinking, Binge Drinking

Does the Gender of Initial Contact Affect Premature Termination of Therapy?

Natasha Barnes, Heather Guttormson, Peggy Troller, Marriage and Family Therapy

The decision to engage in therapy is complex and there are many factors that enter into this decision. This study examines the marital and family therapy files closed in a university-counseling center. Gender of the individual who makes initial contact to arrange therapy, therapy modality, and number of therapy sessions completed data was collected. The results of this study show that the number of therapy sessions completed in marital and family therapy are significantly increased if the female member of the couple or family makes the initial contact.

Keywords: Gender, Initial Contact, Therapy Termination, Premature Termination, Family Counseling

Modeling Oxygen Concentrations in Reaction Diffusion Systems

Mark Anderson, Frances Butek, Andrew Dettinger, Daniel Hecker, Mark Osegard, Applied Math and Computer Science

This research describes our expository research into the nature of the mathematical principles governing a biological reaction-diffusion system, specifically as they pertain to the diffusion of oxygen through a muscle fiber. While oxygen does readily diffuse through a cellular membrane and into a muscle fiber on its own, oxymyoglobin increases the overall amount of oxygen available in the cell. This binding of oxygen to myoglobin facilitates the diffusion process. In order to model such a process, we first developed a general three-dimensional model of diffusion where no reactions are occurring or are accounted for. Once developed, it is then applied in a one-dimensional setting, without reactions, to explore the properties of the model. This model is then expanded to account for the addition of reactions, which occur during diffusion, specifically the reaction between oxygen and myoglobin. Finally, the model is rescaled to three dimensions to more realistically model the diffusion of oxygen, facilitated by myoglobin, within a muscle fiber. These tools allow us to analyze the concentration of oxygen in a muscle fiber and to predict the likelihood of oxygen debt based on the amount of myoglobin present.

Keywords: oxymyoglobin, myoglobin, biological Ohm's Law, Fick's Law, muscle respiration, diffusion equation, reaction-diffusion systems, math model

Listen to your Prescription!

Jenny Syverson
Undergraduate Student, Packaging Engineering

Introduction, development, and history of Audio Prescription Labeling systems

A new technology in the pharmaceutical industry has arrived. This technology is Audio Prescription Labeling (APL), and it has been around since April of 2001. These computerized systems are intended to help individuals with a vision impairment, reading disability, dyslexic or cognitive disability, and senior citizens safely self-medicate. APLs have recently arrived because the need for them is greater now, the technology is modern, and it has just been revealed that they provide a strong sense of independence, which is perceptibly important to individuals with vision impairments. Although this technology has not been a big success due to the high cost barrier, it is a very likely prediction that it's popularity will grow.

This paper will illustrate how Audio Prescription Labeling systems prevent deaths and injuries, save cost, and time to promote an improved quality of life. The market for APLs is large and expanding and there are currently three different APL systems. This article will discuss these factors as well.

Packaging plays a vital role in preventing medication errors. Different drugs must be distinguished to prevent mix-ups in administration, barcode labels are needed to scan bedside in hospitals to eliminate dispensing mistakes. Labels need to provide clarity with audible labels used for patients who may be unable to see, read, or comprehend the instructions (Greenberg, 2001 p. 34). According to Eric Greenberg, an attorney who specializes in food and drug packaging law, "A sometimes deadly and undeniably costly reality, medication errors are being attacked by industry and government in a range of ways, with packaging structural design and labeling leading the charge" (Greenburg, 2001 p. 34).

"Doctors, nurses and pharmacists worldwide are constantly prescribing, dispatching and administering medication in an environment where, at any time, a simple human mistake can lead to tragic consequences" (Pelton, 2002). This statement implies that APLs, one of which completely eradicates human errors, are necessary if we want to avert these consequences.

APL originated from the precedented talking chip found in Hallmark's greeting cards. Hallmark was the first company to manufacture products that utilize microchip technology ("Did you just..", 1997). After studying talking greeting cards, Pharmacist and President of Millennium Compliance Corporation (MCC), John Dobbins, designed the Talking Rx, which is the first

of a new class of "talking prescription containers." The first prototype was constructed in 1996, a few years after Hallmark's cards were conceived (MCC, 2000). It wasn't until April of 2001 that the device became publicly available (Renstrom, 2002). MCC is a company that specializes in the design and manufacture of products that increase medication compliance and reduce medication-related problems (2000).

Prevents deaths and injuries

Serious and fatal problems such as wrongful drug administration, drug dispensing errors and the improper use of medications have been happening all too frequently. Authenticating this statement, Peter Klein, R.Ph., conveys, "Medication errors have been in the forefront of the news lately. The seriousness of this issue has been articulated by Institute of Medicine reports that state up to 2 million people are hospitalized from side effects or reactions to prescription drugs" (Klein, 2001). This is another reason why new technology, like APLs, is being invented and introduced.

Eric Greenburg (2001) states that there are currently close to 100,000 deaths a year that result from "injuries caused by medical management." Over half of these deaths are attributable to medical errors: errors that could be prevented. It's been determined that these blunders are a leading cause of death in our nation (Greenburg, 2001 p.34). According to an Institute of Medicine report, there are four types of medication errors: (1) Diagnostic, such as error or delay in diagnosis; (2) Treatment, including errors in dosing or method of use of a drug; (3) Preventive, including inadequate monitoring or follow up;, and (4) Other, such as failure of communication or of equipment (Greenburg, 2001 p.35).

By removing the enormous financial obstacle that comes with the implementation of computerized systems in hospitals, nursing homes and pharmacies, and by relying on APL and like systems, we will prevent in excess of 7,000 deaths and close to 250,000 injuries a year that are caused by medical errors (Graham and Snowe, 2001).

Members of The Institute of Medicine authored the book, *To Err is Human: Building a Safer Health System*, and they convey a conclusion drawn from research: "…the automation of clinical, financial, and administrative transactions is essential to improving quality, preventing medical errors and improving efficiency" (IoM, 2001). Going on to convincingly plead their case: "Information technology must play a central role in the redesign of the American healthcare system if substantial quality improvement is to be achieved" (Kuhn, 2001). It provides objective, timely, and authoritative information concerning health (National Academy of Science, 2003).

Conclusively, deaths as a result of medical and medication mistakes are extraordinarily high. Unfortunately, it's a known reality that the number of annual deaths from these errors is almost equivalent to the number of annual

deaths resulting from motor vehicle accidents (43,458), breast cancer (42,297), and AIDS (16,516) combined (Institute of Medicine, 2000 p.26). Yet again, over half of these deaths are avoidable. Is this reason enough to justify APLs and state, "We need to embrace this technology"?

Saves costs and time

Audio Prescription Labeling systems will save vast long-term financial costs: "Preventable adverse drug events increase hospital costs by $4,700 per unnecessary hospital admission (or nearly $100 billion a year (Closing the Gap, Inc., 2001))" (Graham and Snowe, 2001). This means that there are over 21 million needless admissions per year.

Medical Errors Reduction Act of 2001

In May of 2001, the United States Senate proposed a bill that aims to provide $1 billion over a 10-year period in order to fund new information technologies that will reduce medical errors that are too expensive for many hospitals and nursing facilities to afford (Kuhn, 2001). According to Herb Kuhn (2001), Vice President of the Premier, Inc. Advocacy, "The legislation's establishment of this grant program would effectively mitigate the most formidable barrier to hospitals' implementation of new, life-saving technologies: cost." Premier, Inc. is an alliance that includes more than 1,800 leading non-profit hospitals and health systems (Kuhn, 2001).

US Senators Bob Graham and Olympia Snowe applaud the grant and inform us "New technologies have already been proven to reduce adverse drug events, the subsequent deaths and injuries, and medical costs (Graham and Snowe, 2001).

No one can better relay why APL and other electronic systems are not yet a success than Herb Kuhn, VP of Premier, Inc.: "In the absence of a national commitment and financial support to equip our health system with such an infrastructure…progress on quality improvement will be painfully slow" (Kuhn, 2001). How very unfortunate considering the positive and live-saving affects that could stem from dedication to information technology. The bill has not yet been passed.

APL systems will save time, and therefore money. APLs prevent pharmacists from having to answer questions from patients who cannot read the print on pill bottles, and keep patients from calling in the wrong prescriptions which, in turn, causes the pharmacist to have to make timely changes when the patient arrives at the store (Lorentzen, 2002).

Speaking on behalf of the patients regarding increased prescription costs, Pharmacist John Dobbins argues, "Insurance companies should cover the products because with increased adherence to medication they'll see decreased costs, with fewer emergency room visits because of adverse drug effects" (Lorentzen, 2002).

The market is there

Presently, 120 out of 284 million Americans (42% of the population) experience difficulty reading or understanding the directions and warnings on their prescriptions (Klein, 2001).

Figure 1 displays segments of the US population who benefit from APLs:

Health Illiteracy and Visual Disabilities in the U.S.
Source: Klein, 2001

4% Dyslexic/Cognitive Disability
2% Seniors with Severe Visual Impairment
3% Blind/Low Vision
58% Remainder of US Population
33% Illiterate
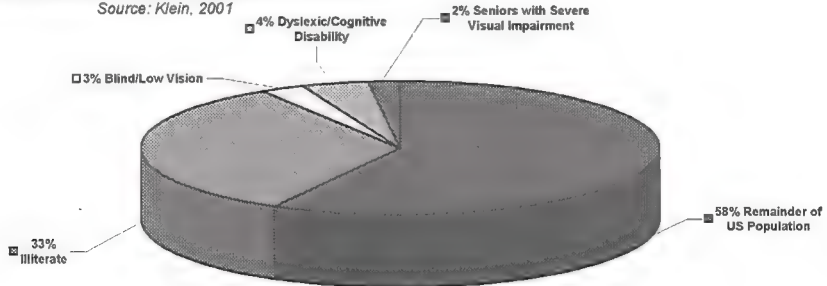
Evidently, there is a large national market for APL technology. According to Neil Osterweil of WebMD Medical News, "With the graying of the US population (see Figure 2), the number of people with age-related vision problems is also expected to rise dramatically. The incidence of visually disabling conditions such as macular degeneration, diabetic eye disease, glaucoma, and cataracts increase sharply after age 65" (Osterweil, 2001). Consequently, "Many more people will be at risk for taking the wrong drug at the wrong time or in the wrong amount.." (Osterweil, 2001).

With the high number of health illiteracy and visual disabilities illustrated in Figure 1, Audio Prescription Labeling must succeed. And with age-associated vision problems constantly on the rise, it is plain to see that changes, such as new technological advancements in home health care, have to be made.

> The United States Census Bureau reports that at least 18% of Americans over the age of 65 have a functional limitation seeing words and letters or are unable to see words or letters. There are currently more that 35 million Americans over the age or 65, and approximately 6.3 million may not be able to safely read the directions that appear on their prescription labels (Klein, 2001).

Figure 2 illustrates the current population, along with projections that portray "The Graying of America" (Klein, 2001):

Number of Seniors with Visual Disabilities
Source: Klein, 2001
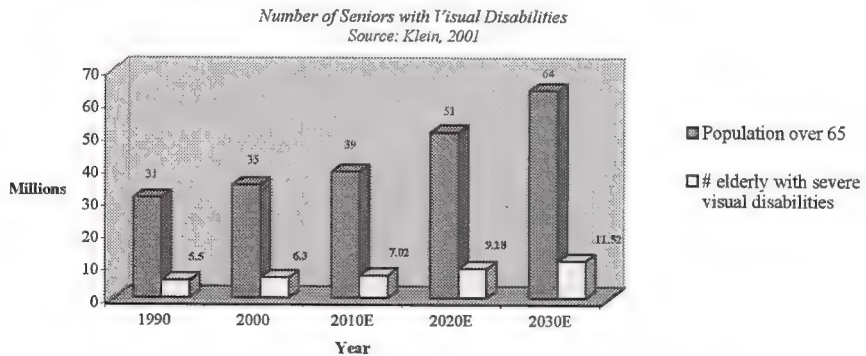
As indicated by several prescription utilization reporting agencies, "seniors over the age of 65 consume, on the average, thirty-six filled prescriptions annually. Therefore, in the year 2000, seniors experiencing a visual impairment consumed over 227 million prescriptions" (see Figure 3) (Klein, 2001). This assessment shows the need for APLs that will allow this population to self-medicate.

Figure 3 displays the number of prescriptions taken by visually impaired seniors:

Number of Rx/yr taken by Seniors with Visual Disabilities
Source: Klein, 2001
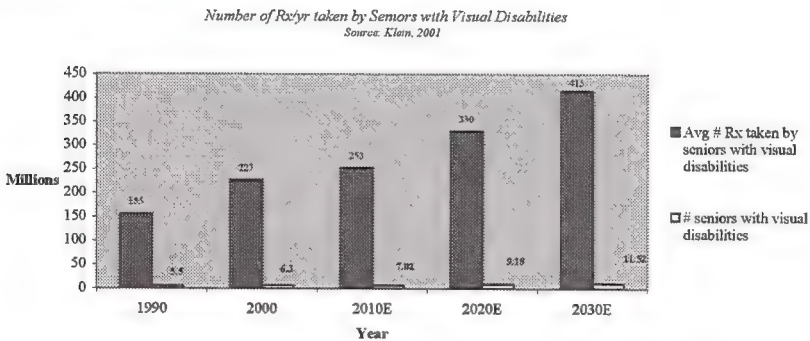
These statistics relay the essentialness for APL systems. Systems such as these will greatly aid in the elimination of non-compliance because they safely convey the information and instructions on prescription labels. Amy Lorentzen of the Houston Chronicle persuades, "With an aging population that's growing, and the multiple millions of visually impaired people in the United States, talking labels are something the medical community has been asking for to prevent dangerous mistakes" (Lorentzen, 2002).

Improves quality of life

APL provides the patient with a strong sense of freedom. Carol Gillespie, a user of MCC's Talking Rx device, informs, "...I am legally blind, and I feel as though the Talking Rx is easy to use because you don't have to take the lids off the bottles to feel the shape of the pill, or ask for help from others. It enables me to be independent. I don't have to put Braille tags on the prescription bottles, which often fall off..." (MCC, 2000). And since only a small percentage of our nation's population (less than 1%) can read Braille, "which renders Braille prescription labeling useless for the majority of the population" (Klein, 2001), APL is the solution to health illiteracy, no matter what the cause. In addition, "the labels make it easier for some patients to stay in their homes or assisted living facilities instead of having to move to nursing homes" (Lorentzen, 2002).

Graig Harriman, an extremely near-sighted user of En-Vision America's ScripTalk APL, communicates, "In the past, I remembered to take the four medications I am on based on the pill shape and color. Now that I have ScripTalk, I feel a lot more comfortable knowing that I'm taking the right pills and the right amount. It provides me with a feeling of freedom and relief" (Alexander, 2002).

Current APL systems

There are currently three companies that have developed these systems. The first corporation to design an APL system is Millennium Compliance Corporation of Southington, Connecticut. MCC has invented the Talking Rx audio reader. The initial prototype of the Talking Rx was built in 1996 (MCC, 2000). The second company to renovate this technology is ASKO Corporation based out of Stamford, New York with the Aloud Digital Audio Labeling System. The first prototype of Aloud was constructed in 1999 (ASKO Corp., 2002). ASKO Corporation (2002) is a manufacturer of high quality digital audio labeling products. They specialize in developing handicapped assistive devices and vision aids. En-Vision America, Inc., based out of Normal, Illinois, is the third and final company (to date) to remodel this technology. ScripTalk was fabricated in 2000 (En-Vision America, 2001). En-Vision America (2001) specializes in developing assistive technology products for low vision and blindess.

Talking Rx	*Aloud*	*ScripTalk*
Audio label is white device	Audio label is black device below bottle	Audio label is on bottle

ScripTalk is the most expensive initially, but is by far the most techni-

cal of the three. Unlike the other two, the unique "smart label" is paper-thin and contains an antennae and a microchip. It consists of: a speech-synthesized translator (ScripTalk), a thermal transfer printer with an RFID (Radio Frequency Identification Technology) programmer, and "smart labels." What happens is the printer prints and programs a special RFID label when prompted. The label is then put on the bottle, taken home and placed within an inch of ScripTalk. Next, it "Sends out power that activates the microchip through the antennae and then flows back through the air and into the reader to translate the text into manufactured speech" (Garrison, 2002). The cost is $275 to the consumer for the synthesizer, and $1 for each "smart" label. The pharmacy buys the printer, which costs $1500 (En-Vision America, 2001). Fortunately, these prices are expected to drop (Bryant, 2002).

ScripTalk is human-error free and the only truly pharmacy-based system. This APL system allows the consumer to only play back the information. Thus, the information can never be altered or erased. There are two sizes of labels: one standard and one small (for insulin vials). The size and type of packages is limitless when using this APL. ScripTalk speaks all the necessary information including the prescription number, which gives the patient a sense of independence because they can order their own refill. There is a one-time only cost to the patient, and the pharmacist doesn't waste any time printing the label. ScripTalk is break-resistant, water-resistant and has loud sound output (En-Vision America, 2001). It is also the only one of the APL systems that doesn't require sighted intervention. This means that no device, such as the Aloud audio label or Talking Rx unit, is required to remove from small vials. "Any talking label needs not to interfere with insulin drawing" (Bryant, 2002). Ed Bryant of the Voice of the Diabetic states, "With ScripTalk, a blind person can reliably and independently tell insulins apart" (Bryant, 2002).

Furthermore, no bulk is added to the label or container unlike the other two systems. ScripTalk currently only has bilingual ability (English and Spanish), but this will soon change. Within a year, ScripTalk will have eight times the storage capacity of the present 60-second system, so each audio label will offer far more data to the user (Bryant, 2002). Pharmacies are presently skeptical about purchasing the printer and welcoming this technology because they want a guarantee ScripTalk will pay off. According to David Garrison of En-Vision America, "Pharmacies won't spend the money until they are forced to by law." The law he speaks of is the American Disabilities Act (ADA). There is a specific regulation which in part, basically summarizes, "If there is a product or technology out there, the disabled have a right to have access to it, no matter what the cost" (Garrison, 2002). The specific law is from Title II, 28 CFR PART 35, and is entitled, *Nondiscrimination on the basis of disability in state and local government services.*

ScripTalk has been used in VA hospitals since the fall of 2001 and went out to pharmacies seven months ago. Although it's known that half a dozen sold the first week, sales figures have not been disclosed (En-Vision America, 2001). According to Pete Klein, R.Ph. and VP of En-Vision America, the company "has had a tremendously positive response from the pharmacy industry to the ScripTalk technology" (Klein, 2001). ScripTalk is currently being sold at Kohll's pharmacies located in Omaha, Nebraska (Garrison, 2002).

Aloud is of lower cost and quality than ScripTalk. It also contains a microchip in the "audio label." This product is a 60-second digital recording system that consists of a player, audio labels and a microphone. In order to record a message, the pharmacist inserts the microphone into the player and holds down the "talk" button. At home, the patient then puts the audio label with bottle into the player and pushes down with a constant pressure in order to hear the message (ASKO Corp., 2002).

The cost of Aloud is $78.75 for the Model 100, which doesn't include a microphone or audio labels (the pharmacy occupies them free of charge), and $88.50 for the Model 200, which includes a microphone and three audio labels. The second model is intended for use with a qualified caregiver. The patient needs to purchase additional labels ($11.95 each) in order to take simultaneous prescriptions (ASKO Corp., 2002).

Like ScripTalk, the message cannot be erased or altered (for the Model 100 only), and the device is relatively inexpensive, as well as each additional label. Aloud can identify any size bottle that fits onto the 1 inch diameter audio label surface. This APL system has an earphone hook-up for privacy, and the number of times the message can be played is limitless. The patient needs only purchase one player unit. The message produced has high fidelity audio, and any language can be recorded (ASKO Corporation, 2002). Allegedly, the pharmacist "Doesn't want to take the time to record a message" (Garrison, 2002) because again, time equals money. The main disadvantage is that the device requires a significant amount of downward pressure, which makes its use difficult for senior citizens who may have problems with arthritis.

According to Vincent Pricolo of ASKO Corporation, approximately 4,000 units have been sold of the Aloud system to date (Pricolo, 2002). Aloud has been around for over a year and a half. This APL system is available in several southeastern and east coast pharmacies (Knoll, 2002)

The **Talking Rx** is the least expensive, and takes a more simple approach to APL technology. It contains a microchip that records and stores information and then plays back the recorded message, much like the Aloud. The difference is that there is no separate recorder – each unit has the capacity to record. "Where the Aloud requires a different audio label on each prescription, but only one playback unit, each Talking Rx unit is self-contained" (Bryant, 2002). This device is essentially a "60-second digital recording device that attaches to the bottom of a vial. Each Talking Rx has an internal microphone and recessed recording button. Using the provided stylus, the pharmacist or caregiver inserts it into the recording hole and pushes down while speaking into the device. The message is then recorded" (Dobbins, 2002). The patient pushes an on/off button to play back the message at home. The cost of the device is $15.00. Though this is very inexpensive, each APL system is in fact a label; therefore, each prescription the patient takes requires a different APL system (MCC, 2000).

The bright red button needs only be lightly touched. This benefits patients with arthritis and visual impairments. Messages can be recorded and played over and over, any language can be recorded, and it's completely water-resistant. On the other hand, the volume isn't very loud, the message can be altered or erased if the patient fumbles around with the unit, and again, the pharmacist typically "Doesn't want to take the time to record

a message" (Garrison, 2002). (MCC: all).

The main drawback is that although this APL system fits five different size pill vials, only round prescription bottles can be used. The Talking Rx isn't as durable or shatterproof as the other two and it runs off three watch batteries that will need to be replaced when dead. The other two APL systems have unlimited battery use.

As for the Talking Rx, sales figures are proprietary but what Mr. Dobbins did state is, "..we have several thousand in circulation" (Dobbins, 2002). This system has also been available for approximately a year and a half. The Talking Rx is sold in numerous pharmacies in the US on the east and west coasts, as well as in the UK (MCC, 2000).

When it comes to liability, all three systems have back up printed labels. They are break and shatter resistant, have a one-year warranty, and none will play back fumbled messages. Where the ScripTalk possesses unparalleled reliability, the dependability of the Aloud and Talking Rx relies solely on pharmacists and caregivers; both of which are human (MCC, 2000, ASKO Corp., 2002, En-Vision America, 2001).

Following much research, it has been strictly decided that ScripTalk is the best system. In the long run, and in most cases, the price of ScripTalk will actually defeat the prices of Aloud and Talking Rx due to the high number of patients who take multiple medications. Plus it's far more technical and dependable. What's even more is this system supplies the most independence. ScripTalk is the victor for the foreseeable future.

APL will succeed

After conveying the high number of deaths and injuries that will be prevented, the large volume of costs that will be saved, the high market for APL systems, and the overall improved quality of life that will be provided for patients, it makes sense to expect that this technology will remain in circulation, and become increasingly more accepted. We can all agree that "Taking medication properly is as important as taking the correct medication" ("The Case of..", 2002). APLs ensure that both of these important factors are obtained. Therefore, APL ought to be universally embraced and put into practice. What it comes down to is; in the instance society doesn't embrace this new technology, a foolish mistake would be made and the consequences frustrating and dangerous to all involved.

Eric Greenburg concludes his article, Packaging as Antidote to Medication Errors, with: "Packaging, as usual, plays an important role in attacking an issue relating to consumer products. With medication errors, virtually all aspects of drug packaging, from labeling to containers to coordination with electronic systems, present opportunities to address the problem in a meaningful way (Greenberg, 2001 p. 35).

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Tickling Your Clients Funny Bone: A Focus Group Exploration of the Effective and Ineffective Uses of Humor in a Therapy Session

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Introduction

Humor is a tool that most, if not all people, regardless of culture or place in history, use in some form or another. (Engle, 1998) According to Newman (1992), "There has been a paucity of research on the psychotherapeutic value of humor. Until 1970 the predominant trend in psychotherapy literature was to publish anecdotal articles which were either lacking in methodological rigor or theoretical conceptualization."

Thomson (1990) conducted a study, randomly selecting and surveying therapists regarding their use of humor in therapy. He found four themes regarding appropriate humor: 1) the central importance of therapeutic relationship if humor is to be used effectively; 2) the degree of spontaneity in the use of humor by both the therapist and client; 3) the potential uses of humor in encouraging client change, and 4) the altered perception of self, others, and the environment derived from using appropriate humor in therapy. He also found that inappropriately used humor may create an imbalance in the therapeutic relationship, hamper effective communication, and create negative feelings about the therapist in the client.

There have been several recent studies (Elerding, 1998; Engel, 1998; Rehill, 1990) that have indicated there are benefits to using humor in therapy sessions as well as cautions regarding the use of humor. To date, none of the studies reviewed has utilized a focus group approach to investigate the effective and ineffective uses of humor in a therapy session.

Definitions

Many studies (Bloomfield, 1982; McGhee, 1979; Mindness, 1971; Robinson, 1977) are indicative of the continuous quest for a definition of humor. Two of the more recent definitions which lend credence to the interpretations beginning therapists/ counselors may gravitate toward are described in the following two paragraphs.

Ziv (1984) has suggested that there are two categories of humor: creativity and appreciation. Humor creativity involves "the ability to perceive

relationships between people, objects, or ideas in an incongruous way, as well as the ability to communicate this perception to others"; appreciation humor pertains to "the ability to understand and enjoy messages containing humor creativity as well as situations that are not congruous but not menacing."

Branko Bokun (2000) in his book *Humour Therapy 2: The origin and potential of humour*, states that "a sense of humour consists of the ability to perceive the ridiculous side of the mind, its world and its reasoning. The landscape of the mind is frightened, threatening and threatened, and this creates tension. When this tension is assailed by humour, it disappears. The main form of release is laughter . . . however, when life is perceived with a smile, gentler than the belly laugh though it might be, it is still a form of release occasioned by the perception that it is part and parcel of a developed sense of humour." (Bokun, 2000)

Literature Overview

Literature on the use of humor in therapy points in many different directions. For instance, a basic argument resonates over whether humor is beneficial to therapy in general, to the client-therapist alliance, and to the therapeutic process. The issue of who transmits humor and how each person internalizes and assimilates that transmission makes the study of humor somewhat complicated. The most pervasive and lively discussion exists not around whether or not humor is beneficial to the therapeutic process but instead around the operational definition of humor, the intent of the humor, and the context in which humor is utilized and perceived (Franzini, 2001). At best, humor moves the course of therapy and promotes understanding and insight to the therapeutic context. However, if inappropriately manifested in therapy, humor can be used to avoid important issues, to weaken the therapeutic alliance (if humor between therapist and client is incongruent) or—at worst— to demean the client or therapist (Schnarch, 1990).

Humor that is Beneficial to the Therapeutic Process—Effective Humor

In the therapeutic process, humor may serve as a vehicle for progress. These functions can be categorized in four ways which include; relationship building, movement of the therapeutic process, release of anxiety, and promotion of awareness. We speak of humor that is therapeutic by qualifying it as humor that is *perceived* as beneficial or effective by the client and the therapist.

At the most basic level, humor acts to break the tension in the therapy room (Fry & Salameh, 1987; Haig, 1986; Rosenheim & Domash, 1974). This release can lighten a heavy discussion or interrupt an uncomfortable silence. Similarly, joking allows for an easy transition into deeper work (Kubie, 1971).

Humor is a tool by which the therapeutic process can be moved in a forward direction, meaning that it can break a stalemate in the course of therapy (Haig 1986; Rosenheim & Domash, 1986). In the same vein, humor can

facilitate a reframe of situations or problems, giving a different outlook to the client or causing a shift in the pace of the therapy (Pollio, 1995; Rosenheim & Domash, 1986). Another way humor may cause such an effect is by normalizing a situation, whereby the client may see the problem in a universal way allowing them to share more information (Pollio, 1995).

Humor may also serve as a means to strengthen or further the therapeutic relationship. A jovial exchange often promotes a base for a friendly atmosphere, and can assist in the joining process between therapist and client (Haig, 1986; Rosenheim & Domash, 1974). Akin to the deepening of the therapeutic relationship is the surfacing of self-disclosure (Haig, 1986), which may be encouraged in a lighthearted, supportive environment.

Moreover, humor can be used to increase the therapist's awareness of the client, thus advocating understanding (Pollio, 1995; Rosenheim & Domash, 1974). For instance, merriment can ease the atmosphere, permitting the client to feel more relaxed in revealing sensitive issues during assessment (Haig, 1986; Rosenheim & Domash, 1974). Skillful use of humor by the therapist can produce a higher awareness within the client by elevating her/ his social skills through modeling (Pollio, 1995).

Humor that is Antithetical to the Therapeutic Process—Ineffective Humor

Although suitable use of humor is often seen as helpful in the therapy room, the misuse of humor can be equally detrimental. The inability of the therapist or client to use humor may be viewed as problematic, inappropriate, or sarcastic humor (Rosenheim, 1974). Aptly put, "Humor must be used in a caring, loving manner and in an inclusive rather than exclusive way." (Rehill, 1990; Shaughnessy & Wadsworth, 1992).

First, humor is recognized as unhelpful when it allows the avoidance of an issue or emotion (Haig, 1986; Kubie, 1971). For instance, if the therapist or client is uncomfortable when discussing particular subject matter, a joke may interrupt the conversation moving it away from the issue at hand. At other times, difficult emotions can arise, which may cause uneasiness in the client or therapist. If the conversation is guided away to avoid such emotion with humor, this type of interjection is viewed as avoidance, and is thus detrimental to the course of therapy.

Second, if teasing or joking surfaces as hostility in the form of sarcasm, the humor portrayed can be the source of a rift in the therapeutic relationship (Shaughnessy & Wadsworth, 1992). This type of humor may be damaging if perceived as a direct or perceived put-down to the client or therapist (Gladding, 1995 & Pollio, 1995). This type of humor, if rendered by the therapist, can create a power imbalance in the relationship, as it may put the client in a "one-down" position. (Haig, 1986; Kubie, 1971).

Third, joking and silliness, when improperly timed, may do more harm than good (Goldin & Bordan, 1999). When humor is employed in a hap-

hazard fashion by the client, this may be indicative of her/ his symptomology. Inversely, if the therapist interjects untimely humor, the client may perceive the therapist as insensitive and thereby causing a rupture in the fabric of the therapeutic alliance.

Statement of the Problem

The purpose of this study was to explore beginning therapists'/counselors' impressions of the effective and ineffective uses of humor in a particular therapy session. Data was collected by means of a focus group discussion with four participants from the Mental Health Counseling and Marriage and Family Therapy programs of the University of Wisconsin-Stout. The observation of a 20 minute taped segment of a therapy session, followed by a forty minute in depth discussion was video taped at the Clinical Services Center at the University of Wisconsin-Stout, fall semester of 2002.

Research Questions

Two research questions explored were:
1) What, in your opinion are the effective and ineffective uses of humor in this twenty minute segment of a therapy session?
2) How do you view your own use of humor as a therapist and/or if you were the client?

Methodology
Research Approach

After careful discussion, a focus group approach was chosen in order to fully explore the phenomenon of humor from the point of view of beginning therapists/ counselors' point of view as they may have experienced it. A focus group is a particularly useful approach when one wishes to generate theories, explanations, and themes. This type of qualitative study seemed particularly appropriate in trying to find new themes beyond those occurring in literature and research.

Sampling and Selection Procedures

Three students from the class, Theories of Family Process, volunteered as the core group of participants. One is in her first year in the Marriage and Family Therapy program. The other two are currently in the Mental Health Counseling program. This was the making of a convenience sample. A time was determined which coordinated with the availability of our research team. We then attempted to recruit more classmates to participate in this study. Initially, two women in the second year of the Marriage and Family Therapy program volunteered, however, one dropped out before the group discussion occurred. As suggested in Piercy and Nickerson (1996) our sample group was quite homogenous including the unintentional composition of entirely women.

Data Collection Procedures

A twenty-minute segment of a therapy session was viewed by a group of five participants. L and G served as moderators in the room, while K served as assistant moderator, handling refreshments, making introductions, and monitoring the taping process. L was also one of a co-therapy team conducting the session in the videotaped segment which the group viewed. The video footage was selected for its brevity (due to time constraints) and high concentration of humor (the operative variable of this study). In the video, the client couple announced to the therapist team that the female client was pregnant.

Before viewing the taped session, the five participants A, H, J, M, and S were given the question "What, in your opinion, are the effective and ineffective uses of humor in the twenty minute segment you are about to view? Before the end of the taped segment, H needed to drop out, leaving A, J, M, and S. Following the twenty minute segment discussion ensued with all four contributing equally in the discussion. When discussion on the initial question appeared to be exhausted, the moderators stepped out for a brief consultation, then posed an additional question, "How do you view your own use of humor as a therapist and/or if you were the client?" which yielded additional thoughts/themes on the topic of the use of humor in therapy.

Data Analysis

The research team employed the following process to arrive at the emergent themes: (1) Immediately following the focus group encounter, the researchers informally discussed their first impressions of the ideas drawn forth therein. The reactions of the research team members that were provided in this informal forum formed a baseline for probing into the unique findings of the study. (2) The resultant videotaped discussion was then transcribed verbatim for subsequent analysis. (3) A cut and paste technique was utilized to reduce data, analyze, and develop emergent themes via the descriptive model. (4) Consultation by the three moderators focused on the emergent themes uncovered after careful examination of the transcript. The emergent themes were compared with categories already defined by existing literature as effective or ineffective uses of humor in a therapy session. The emergent themes that were not so matched rendered unique findings of the study: those of gender difference in style and perception of humor and humor as ritual.

Strengths and Weaknesses of the Methodology

A focus group approach was quick and inexpensive, and able to capitalize on the synergistic effects of group discussion in developing ideas and concepts. The group was interested in exploring further questions regarding gender and humor which emerged during the discussion, thus yielding the opinion that the group was a positive experience for all participants. The researchers/therapists interacted directly with the participants allowing flexibility in questioning and clarifying meaning. The open ended format resulted in a wealth of rich data. (Percy & Nickerson, 1996)

The collaboration of the researchers allowed consensus on emergent themes. The discourse following the focus group session and in arriving at the emergent themes allowed for investigator triangulation that buttressed the validity of the study.

Although care was taken to not bias the participants, one can never know for sure if the results are generalizable. A malfunction in the tape resulted in a significant gap in discussion. Although the previous topic under discussion was summarized, valuable data could have been lost. It was difficult to assemble a group of people available at the same time and the group was unintentionally exclusively female. This limitation in retrospect was also a strength for developing discussion/questions regarding gender and humor.

Results

The themes that emerged as a result of the focus group discussion reinforced the descriptions of effective and ineffective humor that are present in the reviewed literature. A review the literature suggests that humor is effective when it: (a) joins the client and therapist; (b) releases anxiety; (c) moves the therapeutic process; (d) promotes awareness. On the other hand, humor is ineffective when it serves to a) avoid emotion; (b) demean the client or therapist; or, (c) jumble the timing of therapeutic intervention.

New themes were extrapolated by superimposing the emergent themes of the focus groups study with the points made by the literature and research on humor. Two unique themes that surfaced as a result of this process were that of gender-exclusive humor and ritualistic humor.

Effective uses of Humor as Indicated by the Focus Group

Humor may serve to enhance the client-therapist relationship. This type of humor can put the client and the therapist on the same page, and may deepen the therapeutic alliance. Such humor was noted by a member of the focus group:

> "...it was kind of like you guys were making little jokes to, I don't know . . . to make them feel comfortable . . . that, you know, kind of inviting them to join into that."

Humor may also provide an opportunity to release the tension created by digging deep into serious subject matter. The release of anxiety is a noted benefit to therapy by participant S:

> "I think it's a wonderful stress reliever . . . you know, the people coming in for the first time that have a lot of anxiety about what's going to happen..."

Another way in which humor may benefit therapy is to change the pace of therapy, freeing the process past an impasse.   Participant S articulates this in the following passage:

> "after a certain period of time when people were laughing
> about whatever . . . then out of that would emerge a kind of respectful
> question, in a serious vein . . .so . . . having to do with the work . . .
> the work . . . getting down to the work."

Lastly, humor may provide a medium by which awareness is raised. Our focus group participants did not directly address this last point.   This may be due to the nature of the humor and the topic of discussion, which addressed a pregnancy and did not center on issues of growth for the couple.
Ineffective uses of Humor as Indicated by the Focus Group
If joking facilitates the avoidance of important issues or emotions, it is viewed as detrimental to the course of therapy. Participant A expresses this sentiment, as follows:

> " . . . that if somebody has something kind of more serious
> that they want to bring up and talk about that if you don't give them
> ample opportunity that it might discourage them from talking about it
> or not give them the space that they need to kind of work up to talk
> ing about something serious or they don't feel like it's not the right place. . ."

Ineffective humor also takes on the form of misunderstanding or sarcasm, which can undermine the therapeutic relationship by demeaning the client or the therapist. Participant A suggests:

> "…maybe if you don't really know your client well enough that you
> can't really gauge how they're going to take it . . . that there's really a
> thin line between laughing with people or kind of making a joke that
> they're going to find humorous versus coming across as making fun
> and now we're making light of their problems."

Another way in which humor can erode the therapeutic relationship is when it is untimely. Participant A gives substance to this assertion:

> " . . . if you look at it as a kind of affectionate thing it could almost be
> like interrupting if the timing is not right or the rapport is not quite
> right."

Unique Findings of the Focus Group

Two new and unique findings were rendered by the focus group discussion in regard to humor. The first finding suggests that humor may be used positively as a celebration or ritual associated with a life-cycle change. This finding was labeled as an effective use of humor. The second finding indicates that the gender-specific humor present in a therapy session may help to enfranchise or to disenfranchise a client depending on the gender ratio in the therapy room. In the case of this study, the focus group named the exclusion of the male partner of the client couple as an ineffective use of humor.

Humor as Ritual

An additional type of beneficial humor discovered in our study, was that of humor as celebration or ritual. The use of "humor as ritual" fits Ziv's (1984) aforementioned description of creative humor. In our study, this category of humor was represented by the comment made by Participant M:

> "It's like you recognized that things had shifted, you recognized it shifted, and it was named, the reason for that was named and there was some rejoicing over not just the pregnancy, but the shift that happened in that couple because there was one. And so it was kind of like…I thought of it as the music that went with the celebration."

Imber-Black (1992) describes ritual(s):

> They are a lens through which we can see our emotional connections to our parents, children, and dear friends. Rituals give us places to be playful, to explore the meaning of our lives, and to rework and rebuild family relationships. They connect us with our past, define our present life, and show us a path to our future… (p. 4)

By this definition, humor was named by the focus group as ritual, which is a new meaning created in the qualitative process.

Gender and Humor

The results of our focus-group study reveal that the gender balance in the room plays into how humor is interpreted by clients. As the therapy session was predominated by female participants (3:1), the results of our study connate the overrepresentation of women vs. men in the therapy room. The focus group reported a concern over gender and the humor present in the observed session. One participant expressed:

> "I thought at times, that there was so much giggling going on, and I couldn't see him very well, but I thought that he (the husband) might feel kind of outnumbered, and it sounded more like a baby shower."

The participants also discussed how gender affects the substance of humor. One participant noted:

"Men talk about things and money and jobs, and you know…where women will tend to talk about feelings more and so, the area you are most comfortable in you can joke about."

The humor used in the video segment was identified by the focus group as "female-oriented humor," which, in the context of a female predominated session, was perceived by the focus group as exclusionary to the male client.

Validity and Reliability
Piercy and Nickerson (1996) state, "validity, at its most basic level, is the degree to which the data accurately reflect that which the researcher intends to measure. Through the use of a focus group approach the researchers were attempting to understand the participants' views on effective and ineffective uses of humor in a therapy session. We believe the data to accurately reflect the perceived reality of the four participants in this study. (Piercy & Nickerson, 1996)

The research validity was substantiated by the use of investigator triangulation, whereby the researchers conferred and arrived at consensus on interpretations of the focus group responses. The validity of the study was further enhanced since the findings of the study so closely match the findings of other studies and topics of discussion in the literature concerning humor.

Although reliability of results is not necessarily of great import in focus group research, the procedures utilized in such research are crucial. These researchers attempted to follow a standard, definable protocol for both running the focus group discussion, and in analyzing focus group data. Protocol is described in the methodology section of this study.

Ethical Concerns
Two ethical considerations surfaced during our study. The first point being whether or not it was ethical to use a taped session of a couple currently seeking therapy at the Clinical Services Center with a group of MFT students who may at some time in the future come into contact with them. We decided that since the original therapist was part of the research team and had a signed consent form from the clients stating that their sessions may be used for educational purposes we could use a portion of their session for our focus group. The second consideration involved one of the researchers, who acted both as a facilitator to the focus group and as a co therapist in the observed video. The researchers felt that this therapist/ researcher's presence in the focus group atmosphere may have hindered the responses of the focus group. At the same

time, the presence of this same researcher/ therapist was valuable in answering questions about the observed session posed by the focus group. The answers to these questions provided fuel for more in depth discussion.

Assumptions

It is assumed that all participants were able to articulate their personal definitions of humor and apply their perceptions of the effective and ineffective uses of humor viewed in the jointly observed twenty-minute taped segment of a therapy session. It is also assumed that participants were able to evaluate and articulate how they view their own use of humor in therapy sessions and/or as clients themselves.

Strengths and Limitations

Strengths of our study include the ready availability of therapist-in-training videotaped sessions, convenient focus groups of other therapists-in-training, and the wealth of literature on the topic of humor in a therapeutic setting. An additional strength was the use of the focus group approach, which yielded newly uncovered concepts regarding the effective use of humor in therapy sessions and gender related aspects of the use of humor.

Two limitations of our study include the ethical concerns mentioned above, a homogeneous (not gender or cross-culturally mixed) group, and limited time to develop a research question and conduct the focus group. Another concern was the position of the camera angles on the observed research video, which did not provide a clear picture of the clients' faces. The poor angles may have caused the focus group to misinterpret facial expressions of the clients. One last limitation was the size of the focus group, which, by traditional research standards should have numbered at least 8 participants (Piercy & Nickerson, 1996) whereas; our focus group included four people.

Implications for Therapy

The results of our focus group study implicate considerations similar to those investigated by other researchers who have studied humor, thereby fortifying the validity of this study. Generally, humor is interpreted as beneficial if it helps to build the therapeutic alliance, moves the therapeutic process, releases anxiety, or promotes awareness. Conversely, humor is viewed as injurious to the client if it serves to avoid an issue or emotion, put down the client or therapist, or causes a power imbalance. Poor timing can be equally detrimental. All of these considerations can either further or hinder the therapeutic relationship or the therapeutic process itself. These issues were brought forth in our focus group (with the exception of effective humor facilitating awareness).

In addition, two unique pieces of information surfaced during our study: humor can be a ritual that celebrates an event and/or transition and the style of gender-dictated humor may serve to include or exclude specific persons

from the therapeutic circle.

As a ritual intervention, humor can be used to embellish the therapeutic relationship by allowing the client and therapist to rejoice in the positive aspects of the client/client family/client couple's life through celebration. So often the content of therapy becomes heavy and serious. The humor of ritual facilitates balance between the light and the heavy, neutralizing and harmonizing the overall experience of therapy.

Committed relationships require balance and going through the "ups and downs" of life. Therapy is such a relationship. As suggested by this study, the use of humor as ritual in such contexts is beneficial. Therefore, the use of humor as ritual by therapists should be encouraged when used to celebrate positively perceived life-cycle transitions. As an addendum, the arm of Marriage and Family Therapy, named Narrative Therapy, makes common practice of rituals which mark life-cycle transitions of clients (Nichols & Schwartz, 2001).

Given the subtleties that surfaced in the focus group around gender, the therapist may want to consider the gender balance of the room when choosing humor interventions. According to the recommendations of the focus group, the therapist should also remain aware of and sensitive to the topics upon which humor is based. Should this consideration be neglected, the therapist(s) may risk a loss of involvement of the client which may be ousted from the treatment group as a result of the gender-specific humor being employed.

Conclusion

In summation, the consensus given by the literature on humor attests to the fact that humor is beneficial if it serves to enhance the therapist-client relationship, relieve anxiety of the client, break an impasse in the therapeutic process, or strengthen awareness. Conversely, ill-perceived humor can bruise the client-therapist relationship if it causes a power imbalance, circumvents important emotions or issues, or is poorly timed. As the results of this study suggest, the use of humor as a ritual, which celebrates positive life-cycle changes can enhance the therapeutic alliance. On the other hand, humor that is gender-specific can serve to include or ostracize members of the client family.

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Sister Celine's Methods, Theorems, and Demonstrations

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Hypergeometric Functions

First lets recall some well-known definitions for hypergeometric series. The pochhammer symbol $Z(n)$ is defined by $(z)_n = \prod_{m=0}^{n-1}(z+m)$ $\sum_n c_n$ is a hypergeometric series if $c0 = 1$ and $(cn+1)/cn = R(n)$, where $R(n)$ is a rational function of n. $R(n)$ can also be written as $P(n)/Q(n)$ where P and Q are polynomials. Hypergeometric series are always infinite and very important. This can be seen by recognizing that many of the fundamental functions of analysis are hypergeometric functions: Binomial, Exponential, Logarithmic, and Trigonometric. That is they create a hypergeometric series. You can find out if a series is hypergeometric by using the following procedure.

1. Given a series $\sum_k t_k$. Shift the summation index k so that the sum starts at k = 0 with a nonzero term. Extract the term corresponding to k = 0 as a common factor so that the first term of the sum will be 1.

2. Simplify the ratio t_{k+1}/t_k to bring it into the form $P(k)/Q(k)$, where P, Q are polynomials. (If you can't do this, the series is not hypergeometric.)

3. Completely factor the polynomials P and Q into linear factors, and write the term ratio in the form

$$\frac{P(k)}{Q(k)} = \frac{(k+a_1)(k+a_2)\cdots(k+a_p)}{(k+b_1)(k+b_2)\cdots(k+b_q)(k+1)}x$$

The factor k+1 must be there, so if it is not then multiply by $(k+1)/(k+1)$.

4.   You have now identified the input series. It is the hypergeometric series in the form:

$$ {}_pF_q\begin{bmatrix} a_1 & a_2 & \cdots & a_p \\ b_1 & b_2 & \cdots & b_q \end{bmatrix}; x $$

(Petkovsek, 36).

The following proof will show that $\sum_n c_n = c_0 \, {}_pF_q$. $\dfrac{c_{n+1}}{c_n} = \dfrac{(n+a_1)...(n+a_p)x}{(n+b_1)...(n+B_q)(n+1)}$

Given: For a hypergeometric series,

$$ {}_pF_q\begin{bmatrix} a_1...a_p; x \\ b_1...b_q \end{bmatrix} := \sum_{n=0}^{\infty} \frac{(a_1)_n...(a_p)_n}{(b_1)_n...(b_q)_n} \frac{x^n}{n!} $$

Let $\sum_n c_n$ be a hypergeometric series. Show $\sum_n c_n = c_0 \, {}_pF_q$

Consider the terms cn and recall that for a hypergeometric series, $c_{(n+1)}/c_n = R(n) = P(n)/Q(n)$ so that $c_{(n+1)} = c_n * P(n)/Q(n)$.

If $n = 0$: $c_1 = c_0 * (P(0) / [Q(0)*1])$ or

$$ c_1 = c_0 \frac{a_1 a_2...a_p}{b_1 b_2...b_q} x $$

Now let $n=1$: $c_2 = c_1 * (P(1) / (Q(1)*2))$ or

$$ c_2 = \frac{(1+a_1)(1+a_2)...(1+a_p)xc_1}{(1+b_1)(1+b_2)...(1+b_q)2} $$

Substitute for c_1

$$ c_2 = \frac{a_1(1+a_1)a_2(1+a_2)...a_p(1+a_p)x^2 c_0}{b_1(1+b_1)b_2(1+b_2)...b_q(1+b_q)2} $$

Next $n=2$: $c_3 = c_2 * (P(2) / (Q(2)*3))$ or

$$ c_3 = \frac{(2+a_1)...(2+a_p)xc_2}{(2+b_1)...(2+b_q)3} $$

-Substitute for c_2

$$ c_3 = \frac{a_1(1+a_1)(2+a_2)...a_p(1+a_p)(2+a_p)x^3 c_0}{b_1(1+b_1)(2+b_1)...b_q(1+b_q)(2+b_q)3*2*1} $$

We then get the general form

$$ c_n = \frac{(a_1)_n (a_2)_n (a_3)_n...(a_p)_n}{(b_1)_n (b_2)_n...(b_q)_n} * \frac{x^n}{n!} c_0 $$

Where $(a_i)n = a_i * (1 + a_i) * ...*((n-1) + a_i)$ and similarly for the b sub i's. When rewritten as the following we get what we were trying to show

$$ \sum_{n=0}^{\infty} c_n = c_0 \sum_{n=0}^{\infty} \frac{(a_1)_n...(a_p)_n}{(b_1)_n...(b_q)_n} * \frac{x^n}{n!} $$

The History of Sister Celine

Why is Sister Celine's research so important? "The subject of computerized proofs of identities begins with the Ph. D. thesis of Sister Mary Celine Fasenmyer at the University of Michigan in 1945 (Petkovsek et. al., 54)." At the University of Michigan, Sister Celine developed a method for finding recurrence relations for hypergeometric polynomials. In the past, the customary method was hit-or-miss when seeking a new recurrence relation. She was one of the first to find a systematic approach! Sister Celine's algorithm also yielded general existence theorems for the recurrence relations satisfied by hypergeometric sums.

Sister Mary Celine was born in Crown, Pennsylvania October 4, 1906, to George and Cecilia Fasenmyer. When Mary was only one year old, her

mother died, and three years later, her father remarried a woman named Josephine, who was 25 years younger than he. After graduating from high school, Mary taught school for ten years. She then earned an AB degree in mathematics and a minor in physics at the Catholic Mercyhurst College in Erie, Pennsylvania, which was run by the Sisters of Mercy. The same year (1933) she took her vows and joined the Sisters of Mercy becoming Sister Celine. The Sisters of Mercy had a strong educational program as well as social and medical programs which were dedicated to the care of the sick, the elderly and orphans, both in their homes and in hospitals. Approximately five years later, Sister Celine resumed her formal studies at the University of Pittsburgh to work for her doctorate in mathematics, where she was supervised by Earl Rainville. Her thesis showed how a person can find recurrence relations that are satisfied by sums of hypergeometric terms by a purely algorithmic method. She developed this method further in two later papers. The first paper was "Some generalized hypergeometric polynomials" which was in the *Bulletin of the American Mathematical Society in 1947*. It examined special sets of generalized hypergeometric polynomials containing cases including Legendre's, Jacobi's, and Bateman's polynomials. In this paper, she also proposed some additional relations but without proof (pure recurrence relations, contiguous polynomial relations and integral relations). The second paper was entitled "On Recurrence Relations" which was published in the *American Mathematical Monthly in 1949*. It illustrated the algorithms which she discovered during her doctoral work. Her pioneering research went largely unnoticed at the time! Sister Celine then returned to Mercyhurst College, where she taught mathematics as a professor for many years. The teaching of mathematics became her primary, professional goal and she no longer engaged in research. It is doubtful that she was aware that her thesis would prove to be so important until after she retired. It wasn't

until 1978 that the significance of Sister Celine's methods was realized! Doron Zeilberger had written about the importance of Sister Celines's theorem: "I remember feeling that I was about to connect to a parallel universe that had always existed but which until then had remained very well hidden, and I was about to find out what sort of creatures lived there (O'Connor, 2)."

Sister Celine's Method

In order to understand Sister Celine's Method, we will start with a linear algebra review of the standard method for solving systems of linear equations. First of all we start out with three equations. For example, $2x1 - 2x2 + 2x3 + 4x4 = 16$, $-3x1 + 4x2 - 1x3 - 2x4 = -21$, and $1x1 + 1x2 + 6x3 + 11x4 = 16$. Since we have our system of equations, the next step is to put it into a matrix. After that we want to get the matrix into a row reduced echelon form (RREF). After the matrix is in RREF the solution to the system is apparent. In this case, we do have one variable that is unknown since there are more variables than there are equations in the system. Solving such systems are pivotal in Sister Celine's algorithm and the mechanical processes once used, yield desired solution that is relatively easy to develop as a computer software program that can perform the procedure for us.

Sister Celine's Problem was that she wanted to design and implement an algorithm which sums $f(n) = \sum F(n,k)$. Her idea looks for a recurrence relation that the summands $F(n,k)$ satisfy of the form $\sum\sum a_{i,j}(n)F(n-j, k-I) = 0$ for some i,j that are greater then or equal to one. This is known as the Celine Recurrence. A K-free recurrence has coefficients $ai,j(n)$ that do not depend on k. To solve this we have to find $\{ai,j(n)\}$. Suppose we could solve the recurrence. Then we would know $\{a_{i,j}(n)\}$ i=1...I and j=1...J and $\sum\sum\sum a_{i,j}(n)F(n+i,k+j) = 0$. Then we bring the summation of k inside so we get $\sum\sum a_{i,j}(n) \sum F(n+i,k+j) = 0$. Suppose we have a k-free recurrence. Then our equation would be $\sum\sum a_{i,j}(n)f(n+i) = 0$ and this equation can be explicitly solved. Since we have the equations, we can then take the simplest Celine Recurrence and utilize it which is I=J=1. With this then we have $a(n)F(n,k) + b(n)F(n,k+1)+c(n)F(n+1,k) + d(n)F(n+1,k+1) = 0$. Therefore, we have $f(n)(a(n) + b(n)) + f(n+1)(c(n) + d(n)) = 0$. If we solve for $f(n+1)$ we get $f(n+1)= -[(a(n) + b(n))/(c(n) + d(n))]f(n)$ (Petkovsek, 58).

Here's an example where $F(n,k) = \binom{n}{k}$ and $f(n) = \sum \binom{n}{k}$ If we use the equation

from before $f(n+1)= -[(a(n) + b(n))/(c(n) + d(n))]f(n)$ and we say $f(0) = 1$ then we have $a(n)\binom{n}{k}+b(n)\binom{n}{k+1}+c(n)\binom{n+1}{k}+d(n)\binom{n+1}{k+1}=0$ .Then we divide by $F(n,k)$ and simplify.

$$a(n)\binom{n}{k}+b(n)\binom{n}{k+1}+c(n)\binom{n+1}{k}+d(n)\binom{n+1}{k+1}=0$$

$$\frac{\binom{n}{k+1}}{\binom{n}{k}}=\frac{n!}{(k+1)!(n-k-1)!}*\frac{k!(n-k)!}{n!}=\frac{n-k}{k+1}$$

$$\frac{\binom{n+1}{k}}{\binom{n}{k}}=\frac{(n+1)!}{k!(n+1-k)!}*\frac{k!(n-k)!}{n!}=\frac{n+1}{n-k+1}$$

$$\frac{\binom{n+1}{k+1}}{\binom{n}{k}}=\frac{(n+1)!}{(k+1)!(n+1-k-1)!}*\frac{k!(n-k)!}{n!}=\frac{n+1}{k+1}$$

$$a(n)+\left(\frac{n-k}{k+1}\right)b(n)+\left(\frac{n+1}{n-k+1}\right)c(n)+\left(\frac{n+1}{k+1}\right)d(n)=0$$

After these computations we have all we need to find the LCD and in this case it is $(k+1)(n-k+1)$. Therefore our equations is $a(n)(k+1)(n-k+1) + b(n)(n-k)(n-k+1) + c(n)(n+1)(k+1) + d(n)(n+1)(n-k+1) = 0$. After we have this we want to express each coefficient as a polynomial in k. Therefore we have $(k+1)(n-k+1) = -k^2+kn+(n+1)$, $(n-k)(n-k+1) = k^2-2kn-k+n^2+n$, $(k+1)(n+1) = kn+k+n+1$, and $(n+1)(-k(n+1)) = -k+ n^2+2n-k+1$. Given these equations, we have $-a(n) + b(n) = 0$, $n*a(n) + -(2n+1)b(n) + (n+1)c(n) - (n+1)d(n) = 0$, and $(n+1)a(n) + (n^2+n)b(n) + (n+1)c(n) + (n+1)^2d(n) = 0$.
We can then put the coefficients into matrix form and put it into row reduced echelon form:

Calc: $R_2+nR_1 = R_2$

Calc: $R_3 + (n+1)R_1=R_3$

$$\begin{bmatrix} -1 & 1 & 0 & 0 & 0 \\ n & -2n+1 & n+1 & -n+1 & 0 \\ n+1 & n^2+n & n+1 & (n+1)^2 & 0 \end{bmatrix} \implies \begin{bmatrix} -1 & 1 & 0 & 0 & 0 \\ 0 & -(n+1) & (n+1) & -(n+1) & 0 \\ 0 & (n+1)^2 & (n+1) & (n+1)^2 & 0 \end{bmatrix}$$

Calc: $\frac{1}{(n+1)}R_2=R_2$, $\frac{1}{(n+1)}R_3=R_3$

Calc: $R_3+(n+1)R_2=R_3$

$$\begin{bmatrix} -1 & 1 & 0 & 0 & 0 \\ 0 & -1 & 1 & -1 & 0 \\ 0 & (n+1) & 1 & (n+1) & 0 \end{bmatrix} \implies \begin{bmatrix} -1 & 1 & 0 & 0 & 0 \\ 0 & -1 & 1 & -1 & 0 \\ 0 & 0 & (n+2) & 0 & 0 \end{bmatrix}$$

Calc: $\frac{1}{(n+2)}R_3=R_3$

Calc: $R_2-R_3=R_2$

$$\begin{bmatrix} -1 & 1 & 0 & 0 & 0 \\ 0 & -1 & 1 & -1 & 0 \\ 0 & 0 & 1 & 0 & 0 \end{bmatrix} \implies \begin{bmatrix} -1 & 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & -1 & 0 \\ 0 & 0 & 1 & 0 & 0 \end{bmatrix}$$

Calc: $R_1+R_2=R_1$

Calc: $-1R_1=R_1$, $-1R_2=R_2$

$$\begin{bmatrix} -1 & 0 & 0 & -1 & 0 \\ 0 & -1 & 0 & -1 & 0 \\ 0 & 0 & 1 & 0 & 0 \end{bmatrix} \implies \begin{bmatrix} 1 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 & 0 \end{bmatrix}$$

$$a + d = 0 \qquad a = -d \qquad d = -1 \qquad a(n) = 1 \qquad c(n) = 0$$
$$b + d = 0 \qquad b = -d \qquad a,b = 1 \qquad b(n) = 1 \qquad d(n) = -1$$
$$c = 0 \qquad\quad c = 0 \qquad\; c = 0$$

$$f(0) = 1$$
$$f(n+1) = \begin{bmatrix} 1 + 1 \\ 0 - 1 \end{bmatrix} f(n) = \begin{bmatrix} 2 \\ 1 \end{bmatrix} f(n)$$

So to solve this system:
$$f(1) = 2(1) = 2 = 21$$
$$f(2) = 2*2 = 4 = 22$$
$$f(3) = 2*4 = 8 = 23$$
$$f(4) = 2*8 = 16 = 24$$
$$f(n) = 2n$$

Therefore $\sum_k \binom{n}{k} = 2^n$ by using Sister Celine's Method.

We define a proper hypergeometric function as:

$$F(n,k) = P(n,k) \frac{\prod_{i=1}^{u}(a_i n + b_i k + c_i)!}{\prod_{j=1}^{v}(u_j n + v_j k + w_j)!} * x^l$$

where it satisfies the following conditions:
1. P(n) is a polynomial,
2. ai's, bi's, ui's, vi's, ci's, wi's are in z
3. $0 \le u, v < \infty$
4. x is indeterminate (i.e. a variable)

In our example $F(n,k) = 1/(n+3k+1)$, we see that it does not satisfy the conditions of a proper hypergeometric. However, if we multiply the top and bottom of the function by $(n+3k)!$ we can see that $F(n,k) = (n+3k)! / (n+3k+1)!$ which satisfies our definition of a proper hypergeometric function.

Celine's Theorem, also known as the fundamental theorem, is that we suppose F(n,k) is proper hypergeometric. Then, F(n,k) satisfies a k-free recurrence relation of the form $\sum_{i=0}^{I}\sum_{j=0}^{J}a_{i,j}(n)f(n-j,k-i) = 0$

for every I and J that are positive integers. Then, there will be a pair (I^*, J^*) that will work with

$$J^* = \sum_s |b_s| + \sum_s |v_s|$$

$$I^* = 1 + \deg(P) + J^* \left[\sum_s |a_s| + \sum_s |u_s| - 1 \right]$$

It holds for every point (n,k) where F(n,k) is not equal to 0; and all the values of F that occur in it are well defined (Petkovsek, 64).

Using Celine's Method in Maple

First we need to be able to identify a hypergeometric series with maple to get the i and j used in her algorithm. To determine whether a series can be put in the form pFq[...] (p and q are the j and i respectfully) in Maple, we can use the convert/hypergeom function. We will first show it with $\sum_{k}\binom{n}{k}^{2}$ as typed into maple the following:

convert(Sum(binomial(n,k)^2, k=0..infinity)hypergeom);

$$\frac{\Gamma(2n+1)}{\Gamma(n+1)^2}$$

As you can see Maple did not give back an answer in the form of pFq[...] this is because it found an identity in the hypergeometric database that is the answer to our sum. Recall that $\Gamma(z+1) = z!$. Next try the same thing with a more complicated sum $\sum_{k}\binom{n}{k}\binom{2k}{k}(-2)^{n-k}$ again type in the following:

convert(Sum(binomial(n,k)*binomial(2*k,k)*(-2)^(n- k),k=0..infinity), hypergeom);

$$(-2)^n \text{hypergeom}\left(\left[\frac{1}{2},-n\right],[1],2\right)$$

This time we got the pFq[...] form we are looking for (converted into formal

notation it reads $)(-2)^n {}_2F_1\left[\begin{matrix}\frac{1}{2},-n\\1\end{matrix};2\right]$ We now know that we have a hypergeometric

function and can now evaluate the sum with Sister Celine's method.

Sister Celine's Method With Maple

First to use Sister Celine's Method with maple we need the EKHAD package that is available at the following website: http://www.math.temple.edu/zeilberg. After the package has been loaded, which is done by copying the text in the file you get from the web site, pasting it into maple and pressing return. We can try to find the previous sums using Sister Celine's Method and is entered into Maple in a general form of celine((vars)->sum, i, j);

Example 1: $\sum_{k}\binom{n}{k}^{2}$. Although we already were able to get the answer to

this Sum through the hypergeometric database we will still try it with Celine's method. Typing the following into Maple:
celine((n,k)->(n!/(k!*(n-k)!))^2,2,2);

You get back:

The full recurrence is

-(n-1)*b[4]*F(n-2,k-2)-b[4]*(2-2*n)*F(n-2,k-1)-b[4]*(1-2*n)*F(n-1,k-1)-(n-1)*b[4]*F(n-2,k)-b[4]*(1-2*n)*F(n-1,k)-b[4]*n*F(n,k) ==0

along with some other information we do not need at this time. Now all we have to do is reduce the recurrence. As b[4] is a constant in every term it can be dropped and we get this equation that is in normal notation.

$$n\binom{n}{k}^2 - (2n-1)\left[\binom{n-1}{k}^2 + \binom{n-1}{k-1}^2\right] + (n-1)\left[\binom{n-2}{k}^2 - 2\binom{n-2}{k-1}^2 + \binom{n-2}{k-2}^2\right] = 0$$

So to find the recurrence of f(n) we sum over all k and get

$$f(n) = \frac{2(2n-1)}{n}f(n-1) - \frac{2^2(2n-1)(2n-3)}{n(n-1)}f(n-2) = L = \frac{(2n)}{n!^2}$$

Which is exactly what we got before when the convert\hypergeom function

returned the identity. Example 2: $\sum_k \binom{n}{k}\binom{2k}{k}(-2)^{(n-k)}$ Enter the sum into the

Celine function using the i and j that was found with the hypergeometric test.

celine((n,k)->n!*(2*k)!*(-2)^(n-k)/(k!^3*(n-k)!),1,2);

We get back from Maple:

The full recurrence is

-b[0]*(8*n-8)*F(n-2,k-1)-(4*n-2)*b[0]* F(n-1,k-1)-b[0]*(4-4*n)*F(n-2,k)-b[0]*(-4*n+2)*F(n-1,k)+b[0]*n*F(n,k) ==0

Now again all we have to do is reduce the recurrence. As b[0] is a constant in every term it can be dropped so in normal math notation we are left with:

$$n\left\{\binom{n}{k}\binom{2k}{k}(-2)^{(n-k)}\right\} +$$

$$0\left\{\binom{n-1}{k}\binom{2k}{k}(-2)^{((n-1)-k)} + \binom{n-1}{k-1}\binom{2(k-1)}{k-1}(-2)^{((n-1)-(k-1))}\right\} -$$

$$4(n-1)\left\{\binom{n-2}{k}\binom{2k}{k}(-2)^{((n-2)-k)} + \binom{n-2}{k-1}\binom{2(k-1)}{k-1}(-2)^{((n-2)-(k-1))}\right\} = 0$$

Since f(0)=1 and f(1)=0 it follows immediately that

$$f(n) = \begin{cases} 0 & \text{if } n \text{ is odd} \\ \binom{n}{n/2} & \text{if } n \text{ is even} \end{cases}$$

Conclusion

In conclusion, Sister Celine's work revolutionized the application of combinational identities by proving there were algorithmic approaches that have now been implemented in software programs like Maple. This method made finding hypergeometric functions and also finding a recursion using Sister Celine's Method easier.

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Family Impact Analysis of Wisconsin Statutes Addressing Parental Responsibility for Juvenile Behavior

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Introduction

Parents legally have the right and authority to care for their children. They also have a responsibility to make sure that this duty is carried through. Parental responsibility laws attempt to influence and regulate parenting behaviors with the goal of reducing juvenile misbehavior. Are they effective? What are the consequences of established public policies on dimensions of family life? The purpose of this study was to assess Wisconsin Statutes using a Family Impact Analysis in order to show whether those same statutes are beneficial to the family system.

Increasingly family professionals are suggesting that policymakers take a family perspective in policymaking, encouraging them to consider the consequences of public policies on family systems. The first step in doing this is to ask the right questions. Family impact analysis analyzes policy, assesses how it impacts various aspects of family well-being such as family stability, family support and responsibilities, family involvement and interdependence, family partnership and empowerment, family diversity, and specifically how it impacts vulnerable families.

Literature Review

Parental responsibility statutes are not a recent public policy phenomenon. In 1903, Colorado passed a law that made contributing to the delinquency of a minor a crime, and since that time 43 states have passed similar laws. According to Applebome (1996), laws started being enforced concerning parental responsibilities for their juveniles in the late 1980s and early 1990s due to the increases in juvenile crime and street crime. States began a more rigorous enforcement of compulsory education laws to hold parents responsible for their child's attendance at school. In 1995, ten states passed parental responsibility laws that either fined, required counseling sessions, or sometimes imprisoned parents. More states have followed suit in the last decade.

A public attitude toward treatment of juvenile offenders and parental responsibility for such misbehavior is varied. One public survey reported that for crimes children commit with a parent's gun, males and females were equally in favor of holding parents responsible; whites were more in favor than non-white populations, and the older you were, the more in favor of holding parents

responsible you were likely to be (Sourcebook of Criminal Justice Statistics Online, 1995).

Delinquent acts committed by youth are handled in various ways. The percentage of juvenile delinquents that were handled within the police department and released ranged from 16.5% -29.4%, and those who were referred to juvenile court jurisdiction ranged from 63.8%-73% (Juvenile Offenders 2002). One aspect of the juvenile justice system is to rehabilitate minors who commit delinquent acts and protect them with future employment opportunities; on the flip side, the juvenile justice system also states that parents can be held accountable for child's behavior and crimes based on a state-by-state basis. With minor offenses where parental involvement is implied, probation is suggested for the juvenile. Those with a history of offenses are usually referred to a detention center (Juvenile Offenders 2002).

The Supreme Court of Wisconsin stated in Bankert v. Threshermen (1983) that the common law does not make parents routinely liable of damages their children initiated except in four circumstances. They include when the parent negligently entrusts the child with instrumentality that can cause harm; when the child is acting on the parent's wishes or as their agent; and when they know that the child could cause harm and do not stop it. In Hopkins v. Droppers (1926), the first negligent-entrustment case, the court pointed out that parents are not liable by virtue of their parental relationship alone, but instead are liable based on some participation by the parent, whether that is negligent entrustment or negligent failure. (*Negligent entrustment* is when you put something in someone's care or protection and you fail to take proper care in seeing the care is followed through correctly. *Negligent failure* results in failure from the omission of expected or required action (The new oxford dictionary, 2001)). In both court cases, the parents were found not to be responsible for their child's actions.

Although the first court cases in Wisconsin dealing with the parental responsibility issue were as early as 1926, California was one of the first states to apply this concern in ways that affected local levels. In 1988, California legislature enacted Senate Bill No. 1555 that aimed to control violent criminal street gang activity (William v. Reiner 1991). Knowing of or active participation in street gang activities by an individual was decided to be punishable by a misdemeanor or a felony, and the parent was to be held accountable for exercising reasonable care, supervision, and control of their minor child.

A prominent case occurred in Wisconsin in 1995. One fourth-grade student, Jason Hein, diagnosed with ADHD (Attention Deficit Hyperactivity Disorder) was taken off his medication by his parents in April 1989. The parents failed to notify the proper authorities at his school and did not consult with any physician to inform themselves about the consequences of discontinuing the medication (Nieuwendorp v. Hein, 1995). Throughout the following year Jason's behavior was frequently out of control and his teacher, Nieuwendorp, was forced to remove him from the classroom. Upon escorting

Jason outside the room, he refused to walk down the stairs, and pulled Nieuwendorp's hair with enough force that she fell down. The teacher suffered injury to her neck and sued the Heins on account of negligence for these reasons: (a) Jason failed to control his behavior, (b) the Heins failed to exercise reasonable care with respect to their son, and (c) the Heins failed to control their son. The verdict was in favor of Nieuwendorp based on the Heins being deemed negligent in controlling Jason and on the view that the resulting negligence led to the teacher's injuries.

Example of laws/policies aimed at helping parents by educating them and preventing imposed fines have occurred all over the United States. In Bloomington, Illinois, for example, local groups and officials united to make services more available to youths and families (Schults, 1998). The voiced concerns pertained to topics ranging from domestic abuse to juvenile delinquency, and the group looked at options for prevention as well as intervention. They concluded that parenting classes could include in-home counseling in addition to public meetings.

In South Bend, Michigan, a parental responsibility ordinance law aimed at "deterring juvenile problems concerning truancy, drug/tobacco use, firearms control, observance of local curfew, and malicious destruction of personal property or theft" (Baker, 1997). The ordinance established a fine up to $500 for first time offenders or court ordered counseling.
Sonderegger (1997) wrote that in Missouri the topic of discussion centered on changing the focus from parental responsibility to parental notification. This shift was influenced by parental accounts that they felt like the laws were interfering with their parenting space. An example of this would be to notify parents for the first offense if their child breaks the curfew and cite them for a misdemeanor violation the next time.

A great example of parental negligence resulting in parents being held accountable happened in Chicago, Illinois. A 10-year-old boy fired a .22 caliber rifle that was made accessible to him in his parent's house. The result was that the parents faced the charges. However, it was also stated that if the parents underwent counseling, no other charges would be filed (Koziarski 1998).

Overall, one of the places that had set the standard and created international interest was in Silverton, Colorado. There an ordinance was created and implemented that could fine a maximum of $2500 to parents for crimes their children commit. If the parent successfully completed a parent effectiveness program they could be fined no more than $100 (Municipal Ordinance No. 94-132 1995). Naturally, this ordinance had mixed reviews. It created national awareness because communities and parents vocalized their concerns and questions to the extent of the responsibility of curbing juvenile delinquency. This ordinance in Silverton, CO was one of the first laws that was implemented.

Laws that looked at only fining parents for negligence have been

passed in several states. In Dubuque, Iowa, for example, a curfew was set for minors that limited times that they could be in public places or on city streets with a few exceptions. Fines for breaking curfew were set at $25 for the first offense, and up to $200 for fourth and subsequent offenses. Additionally it was said that policy makers were not trying to be parents, but "we would like to think parents understand where we are coming from" ("Parents face fines if kids break curfew," 1998). Although it is not normal for parents to be sued, it is possible. In a case involving a higher monetary consequence, TCF National Bank wanted to hold parents of eight teens responsible for a $90,400 robbery (Novak, 1999).

With all family public policies, there are mixed reviews. Those who are in favor of policies that hold parents accountable base their views on account of evidence that a breakdown within the family system occurs and that juvenile offenses can't be solved without bringing parents into the equation (Applebome, 1996). These laws also force parents to be held accountable for their children and create an awareness of underlying problems. They are not aimed at punishing parents for their child's crimes, but for lack of parental responsibility (actions) leading up to the delinquency (Galler, n.d.). Those who oppose parents being held responsible for their juvenile delinquency base their reasoning on the following points, (a) it is unconstitutional for parents to be held accountable for crimes they did not commit (Collins 1990), (b) you endanger families by further pulling them apart, (c) it adds to the burdens of families in trying to raise their children, and (d), delinquency is a result of a lack of parenting skills, and child misbehavior could involve other outside factors like social development, poverty, teaching practices, and reinforcement (Galler, n.d.). Those opposed also state that enforcing these laws is a reactive rather than proactive stance and problems are compounded.

Specific Wisconsin Policies and Explanation

A few Wisconsin statutes state specifics concerning the role of parent responsibility for juvenile misbehavior.

Restatement of the Law of Torts, § 316 n3, n4 (2001)

N3. "A parent is under a duty to exercise reasonable care so to control his minor child as to prevent it from intentionally harming others or from so conducting itself as to create an unreasonable risk of bodily harm to them, if the parent (a) knows or has reason to know that he has the ability to control his child, and (b) knows or should know of the necessity and opportunity for exercising such control.

N4. Parental liability can also be imposed for negligent entrustment in a situation where a parent negligently entrusts a child with an instrumentality, which may become a source of danger to others" (Nieuwendorp v. Hein 1995).

Wisconsin Statute § 895.035 (2001)
Parental liability for acts of minor child

A parent first needs to have legal or physical custody of the child at the time an incident occurs. If the parent(s) are liable under common law, they are responsible for damages to property (replacing, repairing, and/or removing). Examples of damages include: markings, drawings, writings, etching on property, replacing the value of stolen property, and/or for personal injury attributed to the willful, malicious, or wanton acts of the child.

Wisconsin Statute § 48.415 (2001)

Grounds for involuntary termination of parental rights:

. . . (6) Failure to assume parental responsibility. Failure to assume parental responsibility is proved if parent(s) have never had a substantial relationship with the child. Substantial relationship means the acceptance and exercise of significant responsibility for the daily supervision, education, protection, and care of the child. (This section was deemed important on the basis of needing to know where parents stand regarding their relationship with their child, and how that affects their accountability as a parent. An article by Roberson (1999) details specifics concerning this topic. This article takes into account what is in the child's best interest and states that each occurrence of juvenile misbehavior is weighed seriously.)

All in all, these laws explicitly state that parents are responsible for their child's actions if they have legal/physical custody of their child at the time an incident occurs. Additionally they, as parents, have to deal with the consequences, whether that is monetarily or by taking educational parenting classes. In Wisconsin, the maximum amount that parent(s) may have to pay to a school board or governing body that is claiming occurrence of an incident is $20,000, plus the addition of tax and attorney fees. The maximum amount of recovery from any parents may not exceed the amount specified in section 799.01, with a few exceptions (Parental liability for acts of minor child 2001).

Family Impact Analysis

The Wisconsin Statue § 895.035 (2001) is an example of explicit family policy directed at juveniles and their parents and could ultimately include the possibility of termination of parental rights. The law is intended to influence juvenile and parental behavior and could also affect the family structure if a juvenile is taken out of the home, or a parent is put in jail for not paying resultant fines.

Using family impact analysis criteria developed by the Coalition of Family Organizations (Ooms & Preister, 1988) the application of six guiding principles that serve as assessment criteria on Wisconsin Statue § 895.035 (2001) are presented.

Principle #1- Family Stability

When children are present in the family, it is essential that public policies and programs stabilize families through endorsing family, parental, and marriage commitments, the aim of principle one. Wisconsin Statue § 895.035

(2001) intends to strengthen parental commitment between the parents and their children, but does not necessarily strengthen the commitment between both parents. Ideally it strives to empower parents by making them more aware of consequences, but ultimately it is the parents who choose which path to take, i.e. the degree of parental involvement with their juvenile prevents misbehavior or leads to misbehavior.

The structure of the family is affected if there is a termination of parental rights or a change in legal guardianship. The only way a family could be separated is if the parent would be jailed for failure of paying accrued fines or if the juvenile was put on probation or in a detention center. Ultimately, if either of these situations occurred, it would weaken the family structure.

Principle #2- Family Support and Responsibilities

This principle looks to what extent are families responsible and supportive unto themselves. Ideally, family policies are the most favorable when they support family functioning rather than replace or take over family functions. Government intervention only occurs when parents do not take their parental responsibilities seriously (Wisconsin Statue § 895.035 2001). Society tends to view family responsibilities as private and parents have considerable autonomy in the rearing and socialization of their children until the minor breaks the law. Implementation of this policy occurs at the local level, where communities individually try to provide parenting educational classes as it also tries to build on existing family support networks. The goal is not to punish through fines, etc. but to force, if necessary, involved parenting. The statute does explicitly state that parents are responsible financially for misdemeanors their child commits and enforces such fines on the parents. This could negatively impact families on or below poverty line and those with limited other resources.

Principle #3- Family Involvement and Interdependence

It is essential that family policies take into account all family members in order to be most effective. This principle demonstrates that effective policies need to recognize the importance of family ties and interdependence. This statute acknowledges the extent and complexity of the responsibilities of parenting but clearly requires family involvement. It implies that a juvenile's misbehavior is in part the result of inadequate parental guidance or supervision. Parents are accountable for their minor children and are expected to be influential in guiding actions and consequences of their dependents. The law can also force mediation between family members and the juvenile delinquent, the probation officer, the counselor, a detention facility, and the court system. Competing needs of the adolescent versus those of the parent are considered and decided on a case by case basis with regulations guiding each decision. For instance, the law tries to look out for the best interest of the adolescent and the whole family based on the thesis that parental involvement is the optimal way to do this. However, the policy does not address the mechanism by which

families can do this nor does it address the circumstances (e.g., changes in family structure, poverty) that perhaps contribute to the lack of parental supervision.
Principle #4- Family Partnership and Empowerment
        This principle shows that the most effective way to empower a family is to give them information and choices, and treat all members equally with trust and respect. Ensuring family partnership is a basic intent of this policy. Under this law, families are given decision-making skills and choices, and their choice of which path they take, i.e., the degree of parental involvement with their juvenile, can empower or immobilize them. It implies that parents are partners with authorities with the message of "you do your part and we'll do ours." Family autonomy is breached when the juvenile breaks the law. There is public intervention at that point and parental autonomy to "parent" as one wishes is limited with the state enforcing its value about appropriate parental supervision. The law attempts to support parents by trying to get information into the public arena with informative meetings, educational classes, and other supportive services.
Principle #5- Family Diversity
        The aim of this principle is to identify the best way to analyze a family system. The goal is to look at the family system in a functional way, defining a family by what it does instead of by how it looks. Doing this recognizes the reality of diverse family forms and supports them as they perform their family functions. Wisconsin Statue § 895.035 (2001) is a public law, and therefore applies to all families, regardless of race, ethnic origin, socio-economic status, or cultural expectations and values. It could be interpreted as empowering all families to be more effective in handling their own values and traditions as long as those values include adequate (as defined by Wisconsin policy makers) parental control and supervision of their children.
Principle #6- Targeting Vulnerable Families
        This principle addresses the need for family public policies to prioritize those families who are in the most need, and implement efforts at prevention. As previously mentioned, because this law is not specifically directed at low-income families, it may have the intended effect of further exacerbating their economic problems if they are facing monetary fines for their child's misbehavior. For some families, a lack of access to a variety of resources (e.g., monetary, educational) may result in less ability to adequately supervise their children and subsequently make them more vulnerable to the consequences of parental responsibility laws.

Conclusion

        Laws that establish parental accountability for juvenile misbehavior do so in an attempt to force parents to assume the responsibility that they have been given by virtue of parenthood. Such policies are intended to empower parents in involvement in the discipline of their children. While this is a wor-

thy endeavor, such laws may also have the unintended negative consequence of making a bad situation even worse for already vulnerable families. Effectiveness of the Wisconsin Statue § 895.035 (2001) can be based on your accord or discord with the degree to which parents should be responsible for juvenile misbehavior. Policies involving parental responsibility may also be more effective when coupled with preventive efforts to address broader issues that may contribute to family problems such as poverty and a lack of access to resources.

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A Study on the Mineral Contents in the Seed Coat in Relationship With Canning Quality in Different Dark Red Kidney Beans (PHASEOLUS VULGARIS L.)

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Introduction

Kidney bean, *Phaseolus vulgaris* L., came under cultivation 7,000 years ago in southwestern Mexico (Stone and Stone, 1988). The canned kidney bean is one of the main consumption forms of this agricultural product. Canners are often very particular about specific qualities of the beans. They look for beans with rapid expansion ability, higher drained weight, ease in cooking, and uniformity after the thermal process (Wassimi et al., 1990). Organoleptic properties within the final canned products are one of the major quality evaluation standards. However, not all the cultivars are blessed with equally acceptable quality. Quality problems affecting consumers are often related to the occurrence of bean discoloration, hardness of the beans and breakage of the seed coat following the canning process (Wassimi et al., 1990). In the canning industry, seed coat splitting is considered a factor affecting the integrity of the appearance in the final product and often noticeable to the consumers. Seed coat splitting affects more than just the appearance. It can result in starchiness and excessive viscosity in the final product, although consumers' responses towards to the appearance and texture of the processed beans are the primary considerations driving the standards used by the processors and bean breeders. A cultivar may still be rejected by a processor and consumers if it has poor canning quality, even if it has superior agronomical ability.

Canning quality of dry edible beans, *Phaseolus vulgaris* L., has been found to be related to many factors, such as cultivars, maturity, environmental condition, storage condition, processing variables and handling procedure (Wang et al., 1988; Occena et al., 1991; Balasubramanian et al., 2000). However, very few studies have focused on the influences from various chemical components in seed coat of the kidney bean and how they might relate to bean canning quality among different cultivars. In those studies attempting to correlate links between chemical compounds and canning quality, only a single cultivar or different bean types in the *Phaseolus vulgaris* L family were often used. Lu et al., (1996), in a study of navy bean canning quality, suggested the possibility of a linkage between process methods, chemical composition in the seed coat and canning quality. Soluble pectin content, calcium content in the seed coat and starch gelatinization may play important roles in seed coat splitting (Lu et al., 1996). Calcium chloride is used in the canning industries to enhance the firmness of canned vegetables. Including canned dried edible beans, the use

of calcium chloride results in the formation of metal-pectin complex, which may contribute to the toughening of seed coat and the turgidity of cell walls of the cotyledon tissue (Moscoso et al., 1984; Uebersax and Ruengsakulrach, 1989; Balasubramanian et al., 2000; Lange and Labuschagne, 2000). Pectin substances cross-link with divalent cations, such as calcium, and form intercellular polyelectrolyte gels. The presence of calcium cross-links retards water intake, and increases the firmness due to the formation of calcium pectate (Uebersax et al., 1989). This is a major factor contributing to the textural quality in food (Lange and Labuschagne, 2000). In a study by Moscoso et al. (1984) on hard-to-cook red kidney beans, an association between high calcium and magnesium values in the seed coat to high firmness in cooked beans was proposed. High mineral profiling also seemed to be related to high value in both total pectin substances and high water soluble pectin substances. In another study on canned kidney beans, the level of calcium in brine or soaking water was found to markedly affect the product quality. Increased quality was measured as increased firmness of the canned beans and a significantly decreased percentage of splits. The addition of calcium chloride at 66∞C during the soaking process had the greatest effect on reducing seed coat splits. However, no significant difference in splitting was found in the samples when soaked in brine which was added with sodium chloride (Van Buren et al., 1986).

In general, legume seed weight fractions are: 8.5-10% seed coat, 85 – 90% cotyledon, and 1-3% embryo (Deshpande and Damodaran, 1990). The distribution of nutrients varies in different seed fractions as well as with different cultivars. Cotyledons have abundant proteins and lipids, and are high in ash content. About 80-93% of the crude fiber and 32-50% calcium are often located in the seed coat (Deshpande and Damodaran, 1990). The chemical composition of beans varies greatly among different genotypes. In order to improve a cultivar's physiological properties, breeders often genetically modify cultivated strains by cross-linking with wild species. This further complicates the variation in physiochemical compounds among the commercial cultivars. Mineral content and ash content in kidney bean varies significantly between different cultivars (USDA, 2001). Inconsistency in mineral data from different research resources was found. Some inconsistency may be due to different cultivars, climate, soil composition, and cultural practices. Very few reports have focused on the mineral profile in seed coat; however, most focused on the composition of the whole seed or the cotyledon (Sathe et al., 1984).

The research was directed at studying mineral parameters in the seed coat of three different dark red kidney bean cultivars. These cultivars differ in disease resistance factors and canning qualities. The research attempted to correlate the mineral differences in the seed coat to the canning quality.

Materials and Methods
Sampling and storage
Dark red kidney beans were provided by Chippewa Valley Bean Co., Menomonie, Wisconsin. Three different cultivars (85, 453 and Nickols) were selected for this study. All cultivars were planted in April 2001 in the Menomonie, Wisconsin area. In order to minimize mechanical injury (Heil et al., 1992), samples were harvested manually. During the research period, the dried beans were sealed in Ziploc" heavy-duty freezer bags, and stored in a low temperature incubator (Precision Scientific, Model Freds 815), with a tempera-ture of 24∞C and humidity of 12%. The dry bean samples were graded to size by using a standard bean sieve (No.12, Seeburo Equipment) prior to further experimentation. The fraction remaining in the sieve was selected for this study. The smallest, largest and broken seeds were further removed manually. Canned beans of the three different cultivars were prepared by the Animal and Food Science Department, University of Wisconsin – River Falls. The canned beans were stored at room temperature for 5 months.
Objective measurements
Three cans of each cultivar were randomly chosen for the evaluation set. The percent seed coat splitting was used to evaluate the seed coat integrity after the canning process. The percent splitting was defined as the number of beans with seed coat splitting per 100 beans. After the canned beans were opened, the brine was removed and the samples were rinsed with distilled water to allow for better detection of the defects on the seed coat. The percent of beans with seed coat splitting was determined using the following equation.

$$\text{Percent of seed coat splitting} = \frac{\text{Numbers of beans with splitting in one can}}{\text{Total numbers of beans in one can}} \times 100\%$$

Ash content measurement was modified and based on the AOAC Official Method of Analysis 923.03 and 942.05 (1990), and CEM Use Guidelines. About 15 g of seed coats were ground using a commercial blender (Waring Blender 700, Model 31BL4) for 60 seconds. The powder was collected into an airtight sandwich bag (16.5¥14.9 cm, Home BestTM) and stored in a dessicator. The samples were ignited in an 800∞C furnace for 120 minutes to burn off the organic materials.

All the procedures used for the mineral profile were adapted from the AOAC Official Method of Analysis 2.055 to 2.059 (1980). Equipment used included a drying oven (Stabil-therm" Oven, Blue M electric company) main-tained at 80∞C, a furnace (Fisher Scientific Isotemp 650 Programmable Muffle Furnace), and Atomic Absorption/Atomic Emission (AA/AE) Spectrophotometer (Instrumentation Laboratory, Model S12). The ash samples of approximately 3 g vacuum-dried seed coat were digested with 15 mL 6 M

HCl at a boiling point. Following the initial acid digestion, further digestion was accomplished by adding an additional 10 mL of 6 M HCl and boiling for another 5 minutes. The digested solutions were dissolved with Milli-Q water (Milli-Q" Water Purification System, Millipore Corporation) to 100 mL and further diluted 10-fold to 100-fold for more efficient reading of absorbance. Samples were analyzed for their iron, sodium, calcium, magnesium, and potassium content by using AA/AE Spectrophotometer with an air/acetylene flame. The linearity of each mineral standard solution was determined by measuring the absorbance of standard solution series. Mineral content of each sample was measured and the mineral concentration was determined using a standard curve.

Statistical Analysis

Results were expressed as mean ± the standard deviation of the triplicate experiment results. Data sets were evaluated by using the one-way analysis of variance (ANOVA). T-test was used to evaluate the difference between two cultivars for various attributes. Pearson correlation was used to evaluate the relationship of canning quality and physiochemical properties.

Result and Discussion

Percentage of splits in canned kidney beans is defined as the number of beans with split seed coat per 100 canned beans. The ANOVA data indicated that highly significant statistical differences ($P \leq 0.001$) in percent splits existed among the cultivars. The mean value of split in percentage from different canned kidney bean cultivars is shown in Table 1.Canned products of cv. 85 had significantly fewer splits than the other two cultivars, while canned cv. Nickols had the highest number of seed coat splits per can. This indicated that the seed coat of cv. 85 had a higher ability to maintain its integrity during the canning process. Compared to the other two cultivars, the seed coat of cv. Nickols was most susceptible to thermal process as indicated by the number of seed coat splits.

A study on the correlation between physiochemical properties of kidney bean seed coat and splits could provide important information on the influence of compositional or structural differences on maintaining seed coat integrity during the thermal processing. It may also suggest possible parameters associated with the seed coat integrity during canning and rapid identification methods for those parameters.

Significant differences were found in some mineral contents in the seed coat among various cultivars; an exception was noted in the potassium content (Table 2). Mean separation showed that the seed coat of cv. 85 contained significantly higher calcium content and sodium content than the other two cultivars. Cv. 453 and cv. Nickols did not differ significantly in calcium content. However, cv. 85 and cv. 453 were also significantly higher in sodium content than cv. Nickols. The seed coat of cv.453 was significantly higher in

magnesium content than either cv. 85 or cv. Nickols. Mean difference in magnesium content was not significant between cv.85 and cv. Nickols. The seed coat of cv. Nickols was found to have a significantly lower level of iron than the other two cultivars. Cv. 85 and cv. 453 showed no significant difference in seed coat iron content.

Calcium

Calcium accounts for 20-30% of the total ash content in the seed coat. Calcium content in the seed coat of cv. 85 was the highest (793 ± 34 mg/100g seed coat) among the three different cultivars. The smallest number of seed coat splits was found in canned kidney beans from cv. 85 (2.79 ± 0.22 splits/100 seeds), while canned cv. Nickols contained the highest number of splits and lowest amount of calcium in seed coat. Pearson's correlation showed that the calcium content was significantly correlated with beans splits (r = -0.74, P £ 0.05), (Table 3). This indicated that higher calcium content in seed coat might result in fewer seed coat splits during thermal processing.

In the legume family, 30-50% of the total calcium is contributed to the seed coat (Deshpande and 1990). Calcium is particularly abundant in the plant cell wall. A study on horse beans (*Vicia faba minor* L.) showed that 60% of the total calcium was associated with the cell wall. The presence of calcium ions was believed to greatly increase the stability and cohesion of cell walls due to its formation of insoluble complexes with pectin (Demarty et al., 1984). In the cell wall, the cellulose microfibrils are imbedded in a gel-like amorphous structure consisting of a network of pectin and hemicellulose along with proteins (Bidwell, 1974). The outer part of the cell wall is connected by the middle lamella, which has a gel-like structure and serves as intercellular bridges between cells. Pectin predominates in the middle lamella with a concentration varying between 10-30%. The chemical cross-linking between calcium ions and pectin creates a network structure and additional constraints, which results in strong cohesiveness in the structure (Van Buren, 1991).

Calcium can bind with unesterified pectins by forming a cross bridge between the negatively charged carboxyl groups of the galacturonic acid (Steele et al., 1997). The dimerization of homopolymeric chain sequences is the first event in the induction of interchain association by calcium. In this mechanism, calcium ions are sandwiched between pectin monomers at specific sites by electrostatic interactions with the carboxyl groups of the pectin (Demarty et al., 1984). Calcium linkages with pectin involve many other functional groups besides the carboxyl groups. Strong interaction between calcium and other oxygen atoms on pectin has been reported (Van Buren, 1991; Demarty et al., 1984).

Another form of calcium deposition in the seed coat is the presence of calcium oxalate crystals. In the bean seed coat, calcium oxalate monohydrate has been found to be present in abundance. This monohydrate is stable in water. Total erosion of crystals when exposed to water may take several days,

while the sheath may remain even after the entire dissolution of the crystal. The growth of crystals is generally considered to be controlled genetically. The production of specific crystals and their location can vary considerably among cultivars (Grimson et al., 1982). The crystal growth in the seed coat starts in the parenchyma cells near the hilum, and finished in hypodermal cells. The growth is accompanied by thickening of the cell wall. The exact biological role of calcium oxalate crystals in plants is still unclear, although the possible functions include regulating intracellular pH balance, and protecting the embryo from microbial invasion. In addition, crystal growth serves as building bricks, which parallels with cell wall thickening. This enhances the protective role of the seed coat (Barnabas and Arnott, 1990).

Sodium

Sodium content in the seed coat accounts for only 0.30 – 0.50% of the total ash content. Statistically, however, significant differences (P£0.01) were found in the sodium content of the seed coats among the three cultivars (Table 2). Cv. Nickols had significantly lower sodium than the other two cultivars. Cv. 85 had significantly higher sodium content than cv. 453. A strong negative correlation was found between sodium content and seed coat splits (r = -0.89, P£0.01), (Table 3). This indicated that an increased sodium content present in seed coat might reduce the possibility of seed coat splitting during the canning process. Interestingly, a positive correlation was found between sodium content and calcium content (r = 0.69, P£ 0.05). Increased calcium content was accompanied by increased sodium content in the seed coat.

The function of sodium interaction with divalent ions on the stability of pectin polymerization is still unclear. Some studies have found that the presence of monovalent salt (such as NaCl) at high concentration, can remove calcium from the pectin-calcium network (Van Buren, et al., 1986; Coimbra et al., 1996). However, other studies have found that the presence of 0.1 M NaCl reduces the critical concentration of calcium required for the occurrence of precipitation in the stable pectin solution (Axelos et al., 1996).

Iron

A significant difference (P£0.05) in iron content of the seed coat was found among the three different cultivars (Table 2). Cv. Nickols had a significantly lower amount of iron in the seed coat than the other two cultivars. No significant difference was found in the mean difference of the seed coat iron contents of cv.85 and cv. 453. Iron content in the seed coats was found to be strongly correlated with the bean splits (r = -0.79, P£0.05), (Table 3). This suggested that higher iron content might result in fewer seed coat splits during the canning process. A positive correlation between iron and sodium was also observed in the seed coat of the three cultivars (r = 0.67, P£0.05). Increased iron content in the seed coat could be accompanied by an increase in sodium.

The mechanism of iron transportation in the bean seed is not fully understood. For peas (*Pisum sativum* L.), iron is transported to the seed coat where

it is released and then absorbed by the embryo during the seed development. The form of the iron when released in seed coat has not yet been identified. When absorbed by the embryo, iron complexes with a high molecular weight protein, known as ferritin. As many as 2,000 iron atoms can be stored in each ferritin molecule. However, ferritin has not been detected in the seed coats of the developing pea seeds, which suggested that iron might be adequately chelated in order to prevent oxidative stress in the seed coat (Marentes and Grusak, 1998).

Magnesium

Highly significant differences (p£0.01) were found in the magnesium content of seed coat among the three different cultivars (Table 2). Magnesium content in the seed coat of cv.453 was significantly higher than the other two cultivars. Cv. 85 and cv. Nickols had no statistical difference in their means of magnesium content. As a divalent ion, magnesium functions similar to calcium in pectin polymerization. In a study on the magnesium fertilization on potato firmness (Klein et al., 1982), the authors found that increased magnesium fertilization resulted in increased firmness of the potatoes. They suggested that the increased firmness was associated with the formation of metal bridges between pectins (Klein et al., 1982). However, no significant correlation was found between present seed coat splits and magnesium content in this research. A study on soybeans found that magnesium could only weakly bind to the seed coat cell walls; compared to calcium, the high mobility of magnesium in the seed coat during seed maturation leads to less accumulation of this mineral in cell walls (Laszlo, 1990).

Conclusion

The study showed significant differences in sodium, calcium, iron and magnesium content among the three cultivars studied. Some strong correlations between mineral content in seed coat and canning quality were observed. Significantly negative correlations were found between the percentage of seed coat splits, sodium, calcium and iron content. The presence of certain more highly concentrated minerals (calcium, sodium, iron) in the seed coat may well control the process of softening and maintain the integrity of the seed coat during processing. The formation of a strong network between calcium and pectin may contribute to a rigorous seed coat structure, which consequently results in fewer seed coat splits during thermal processing. The presence of sodium may influence the ratio of monovalent to divalent metal ions, which may influence the textural characteristics of the canned product. Interestingly, a positive correlation was found between sodium content and calcium content. Increased calcium content in the seed coat was accompanied with increased sodium content. A very good agreement between iron and sodium content was also shown in the seed coat of kidney beans Increased iron content in seed coat was accompanied by increased sodium content. In this study, only selected mineral contents in the seed coat were investigated. It could be expected that interactions of other min-

erals with pectin might also influence the structural integrity during the thermal processing.

Acknowledgements

Table 1: *Percentage of seed coat splits in the different canned cultivars of Dark Red Kidney*

Cultivar	85	453	Nickols
Percent splits (splits/per 100 seeds)	$2.79 \pm 0.22a$	$4.67 \pm 0.38b$	$11.22 \pm 0.67c$

Note: Samples were expressed in mean ± standard deviation.
Triplicates were conducted for each cultivar.
Means followed by different superscripts indicate significantly differences ($p \leq 0.05$).

Table 2: *Ash and mineral content of seed coat in different cultivars of Dark Red Kidney Beans based on dried weight*

	85	453	Nickols
Ash (g/100g seed coat)	$2.71 \pm 0.08a$	$2.47 \pm 0.09b$	$2.46 \pm 0.02b$
Sodium (mg/100g seed coat)	$13.87 \pm 1.16a$	$11.9 \pm 0.66b$	$9.36 \pm 0.81c$
Calcium (mg/100g seed coat)	$793 \pm 34a$	$626 \pm 57b$	$618 \pm 41b$
Iron (mg/100g seed coat)	$7.43 \pm 0.74a$	$7.43 \pm 0.99a$	$5.54 \pm 0.55b$
Potassium (mg/100g seed coat)	590 ± 18	526 ± 29	535 ± 32
Magnesium (mg/100g seed coat)	$274 \pm 11a$	$359 \pm 32b$	$269 \pm 15a$

Note: Data are expressed in mean ± standard deviation.
Triplicates were conducted for each cultivar.
Means in a row followed by different superscripts are significantly different ($p \leq 0.05$).

Table 3: Pearson's correlation between bean splits and mineral content of Dark Red Kidney Beans

	r value	Significance of r
Bean splits vs. Ash content	- 0.584	0.099
Bean splits vs. calcium content	- 0.668	0.049*
Bean splits vs. sodium content	- 0.891	0.001**
Bean splits vs. iron content	- 0.794	0.011*
Bean splits vs. magnesium content	- 0.347	0.361
Bean splits vs. potassium content	- 0.400	0.287

Note: * indicates significance at 0.05 level; ** indicates significance at 0.01 level.

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Creating Texture Screens

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An Alternative Photographic Process

This research looks to discuss the origins of texture screens and the principles of how they work. Several different methods of creating screens and applying texture effects to photographs will be described as well as experiments with texture screens and explanations of the results will be shared to tie all the related information together.

William Herbert Mortensen is credited with the invention and development of the texture screen in the 1920's and 30's (http://www.texturefects.com/aboutus.htm , 2002, Para. 2). In 1931, he opened the Mortensen School of Photography and taught over 3,000 students during a period of about 30 years. Between 1933 and 1955, Mortenson also wrote over 100 articles and 9 books on photography (http://www.texturefects.com/mmbook.htm, 2002, Para. 3).

A texture screen is a clear negative film with a somewhat abstract pattern on it that is either laid directly on top of the photographic paper during exposure or can be placed with the negative in the carrier of the enlarger. The screen then prints its positive image onto the paper, adding texture and depth to a photograph.

Texture screens can be used in both non-color and color applications. This paper will concentrate on the non-color or black and white photography applications. Different effects can be achieved depending on how the screen is used. Texture screens may cause a slight loss of contrast, which can be helped by using a paper of higher contrast grade (Kodak, p. 68). Exposure times may also need to be lengthened slightly.

More variations are available with the larger texture screens that are laid on top of the photo paper. The screen is laid emulsion side down, in contact with the emulsion of the paper. A sheet of glass is often used to keep the screen in contact with the paper because the pattern will blur where it is not in contact (Kodak, p. 68). The negative is projected from the enlarger in the normal matter, through the glass and the texture screen, and onto the paper. This method allows for the degree of texture to be controlled. One is able to expose the paper through the screen for the full exposure time, or the screen can be removed at the desired portion of the exposure for a more subtle effect. This method also allows one to diffuse the enlarger image but maintain the sharp focus of the texture (http://www.texturefects.com/qanda.htm, 2002, Para. 10). By using a sharply focused texture screen with a slightly out of focus negative, one can give the illusion of more focus because the eye is drawn to the crispness of the pattern.

Smaller texture screens are less expensive and the problems with dust are easier to control, but there is not as much variation available in the effects. A glass carrier is recommended to keep the two films in contact with each other (Kodak, p. 60). When using the "sandwiching" method, or placing the texture inside the negative carrier, the texture must be exposed for the entire time period, resulting in a quite obvious texture effect. The sandwich method also enlarges the texture pattern to the same degree as the negative. Personal preference and desired effect will help determine which method to use. Texture screens can also be used in combination with each other (http://www.texture-fects.com/qanda.htm, 2002, Para. 12).

Texture screens can be purchased from specialty photography shops and also obtained online from such websites as Texturefects.com. This particular site sells many sizes and textures ranging from a 35mm sandwich type screen for $17, to a 20x24" contact screen for $230. Texture screens can also be made for very little money, and it can be quite fun to develop one's own textures and techniques.

A simple way to make many 35mm size screens is to shoot a black and white roll of film of different textures and patterns. Using strong side lighting creates especially detailed textures (Kodak, p. 68). The film should be underdeveloped by 1-2.5 stops, or about 15% less time than normal (http://www.classicfotos.co.uk/tip_5.htm, 2002, Para. 4). This produces thin negatives so the texture image will be subtler than the subject image. The negatives are then placed into the negative carrier and the pair is enlarged as usual.

Full-sized texture screens can also be easily made. Most translucent materials can be used (Kodak, p. 60), in either their positive or negative form. To print a negative of the texture, simply lay the material over the photo paper, and cover both with a sheet of glass to obtain contact between the surfaces. Depending on the thickness and/or density of the material, exposure time will need to be adjusted.

If the desired effect is for the texture to be printed as it appears naturally, a negative must be made. This can be done by exposing a large sheet of Ortho film in direct contact with the material. The film can be developed in the typical Dektol developer for a continuous tone texture, or in A and B developer for a higher contrast texture. The exact nature of each individual texture may determine the best development method. Once dried, the film can be put into contact with the paper and exposed as usual or slightly longer, using a negative and enlarger in the normal manner.

I experimented by making contact films as well as using the original materials as texture screen overlays when I exposed the photographs. I developed all of the texture screen films in Kodak A and B developer to achieve an "all-or-none" black-and-white kind of texture effect. I used Ilford's Multigrade IV Resin-Coated paper for all of the photographs, and developed them using the traditional Kodak Dektol developer. Here is what I found:
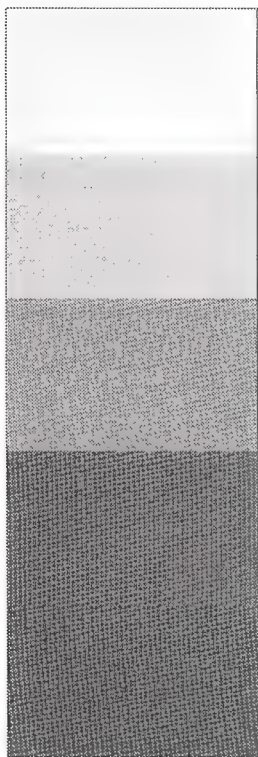
First, I made six test strips using different types of fabrics in contact with the Ortho film for varying amounts of time.

In Test 1, I tried a rather thin and delicate transparent fabric in one flat layer. I exposed it through a sheet of glass at F16 in one-second increments for a range of 1-5 seconds (see fig. 1). Five seconds appeared to have worked well, but in order to make sure that the black areas were completely opaque; I did a second test of this texture.
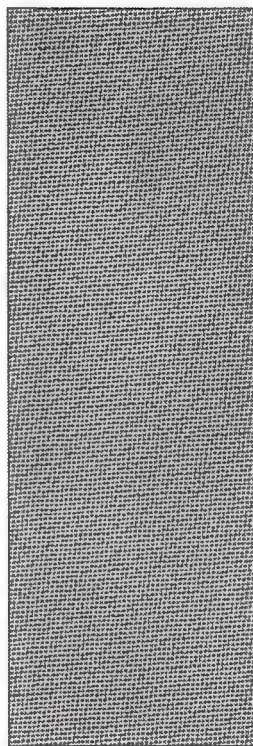

Figure 1.
Test Screen 1, enlarged 500%.

Figure 2.
Test Screen 2, enlarged 500%.

I repeated the former test, but extended the exposure range from 5-10 seconds to create Test Screen 2. It is nearly impossible to tell a difference between these time increments (see fig 2). I was pretty impressed with the accuracy and detail that was captured because I wasn't sure if the threads of the fabric would completely block the enlarger light from getting to the film.

Figure 3.
Test Screen 3,
enlarged 500%

For Test Screen 3, I tried folding the same fabric diagonal to the grain, so the threads would cross at about 45-degree angles. I exposed it at F16, using 2-second intervals, for a range of 2-12 seconds (see fig. 3). The overall tone of the film is about half that of what a single layer of fabric created because the threads criss-cross and cover twice as much area. The close contact of the materials and the accuracy of the film in combination with the high contrast A-B development achieved great detail once again.

I tried rippling the fabric and placing glass over it to create Test Screen 4, a multi-layered texture. I exposed the film at F16, using 3-second intervals, for a range of 3-18 seconds. A longer exposure time of 15 or 18 seconds was needed to see much definition in the areas where there are 3 or 4 layers of fabric (see fig. 4). The differences between the numbers of layers of fabric are quite pronounced. In the 15-second frame, there are areas with one, two, and four layers. Exposure times will need to be lengthened when using multiple layers. The best way to select exposure time is by conducting simple tests of varying exposure, and choosing the best results.

Figure 4.
Test Screen 4, enlarged 500%,
3, 9, and 15 second tests shown here.
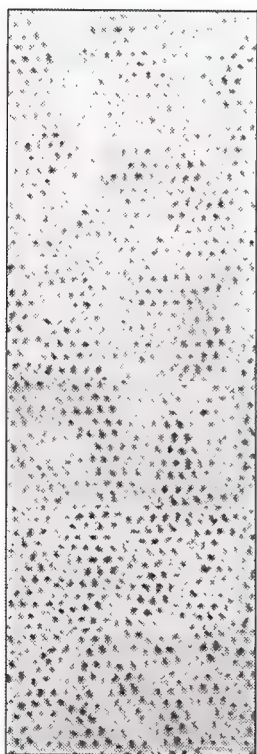
Figure 5.
Test Screen 5,
enlarged 500%.

To make Test Screen 5, I tried a new type of fabric: a stretchy knit that was relatively translucent. I put two layers on top of a sheet of film and under the glass. I exposed it at F16 for 2-seconds intervals, for a range of 2-12 seconds. There is not a drastic difference in appearance from the different exposure times, but the 12-second end is slightly more detailed (see fig. 5).
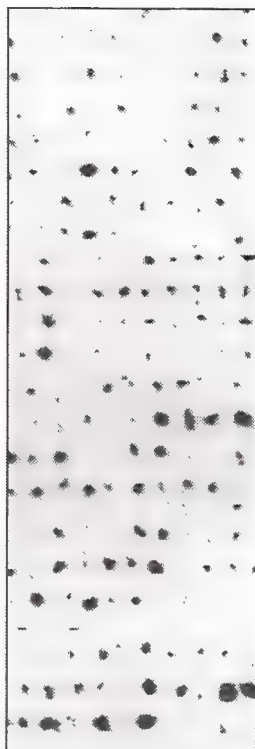
In Test Screen 6, I used a third type of fabric: a nearly opaque, thick, woven fabric. I placed one layer under glass against a film. Because of the thickness of the fabric, a significantly larger amount of light was needed to penetrate it. I chose to expose at F4, using 10-second intervals, for a range of 20-70 seconds. The middle range appears to be the highest quality because most of the spaces between the woven fabric appear, and there are not as many blurred edges from overexposure and light leaks through the holes of the fabric weave
(see fig. 6).

Figure 6.
Test Screen 6,
enlarged 500%.
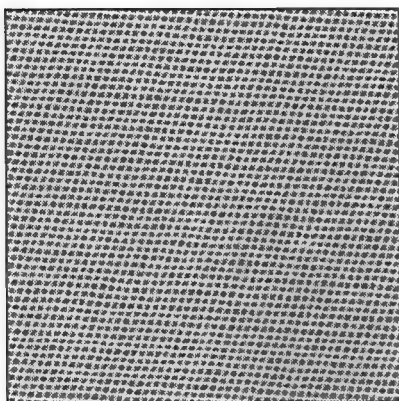
Figure 7.
TS1, sample enlarged 500%.

After making these test strips, I decided on two textures that I wanted to make full sized 8x10" screens of. The first (TS1) was based on Tests 1 and 2. The film was exposed through a single layer of fabric for 10 seconds at F16, then developed it using the A-B process. This created a texture screen with little black squares and it is clear where the threads of the fabric blocked light to the film (see fig.7). This will block out squares of light projected from the enlarger, and will allow light to hit the photo paper in the grid pattern of the threads of the fabric.

I based the second (TS2) on Test 3. It was a diagonal fold of the same fabric, also exposed for 10 seconds at F16 and developed in the A-B developer. It achieved similar results as TS1, but with about twice as much negative space due to the doubling over of the fabric (see fig. 8). This will allow more of the projected light to come into contact with the paper, and will block less light than TS1, resulting in a more delicate texture effect.
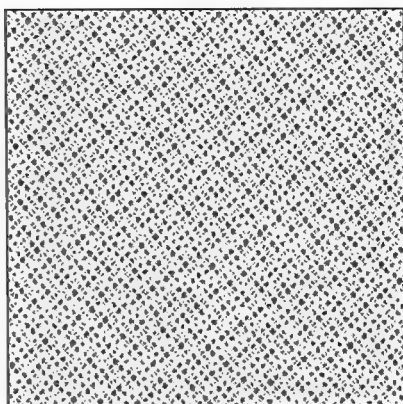

Figure 8.
TS2, sample enlarged 500%.

The following are my experiments with the application of the texture screens that were created on a sample photograph.

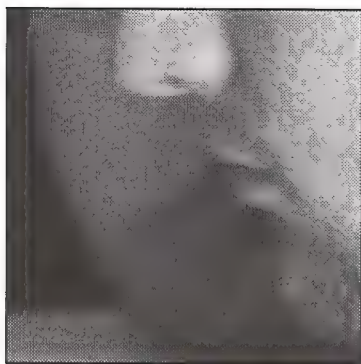Figure 9. Control, actual size.

Figure 10. Control, enlarged 300%.

Because the texture screen will only affect the photo paper where the negative allows light to shine through, the texture will be most noticeable in the dark areas of the positive image (see fig. 9). The control photograph used had a fair amount of dark and mid-tones (see fig. 10). It was exposed with a 0-filter at F8 for 50 seconds. Each subsequent picture was exposed using the same filter and F-stop, but for differing amounts of time.
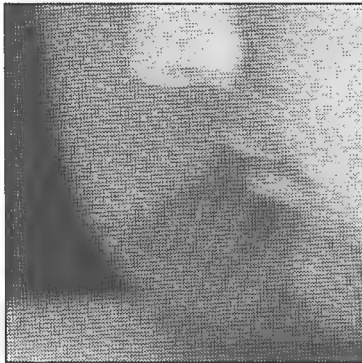
Figure 11. Photo 1, actual size.

Photo 1 was made by laying TS1 over photo paper and under glass (see fig. 11). It was exposed for 65 seconds. The delicate texture lines appear in the black and gray areas of the picture, but not in the white areas (see fig. 12). This is the nature of texture screens that are used in this manner. This screen also decreased the contrast of the photograph slightly.

Figure 12. Photo 1, enlarged 300%.

Figure 13. Photo 2, actual size.

Figure 14. Photo 2, enlarged 300%.

Photo 2 was made with an opposite screen. The fabric, rather than the texture screen made from the fabric, was used. It was exposed for 60 seconds. The overall result and tone of the photo appears the same at first glance (see fig, 13). Upon closer inspection however, you will find it has an opposite effect (see fig.14). The threads of the fabric blocked out the light, creating a fine, white-lined texture throughout the gray areas of the photo.
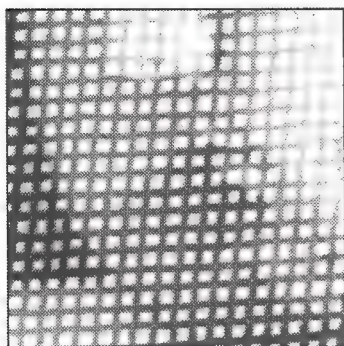
Figure 15. Photo 3, actual size.

Photo 3 was made with TS1 as well, but with a portion of it cut out to fit into the carrier with the negative. It was exposed for 60 seconds. The photo only appears in the weave of the thread, where the texture screen was clear (see fig. 15). The subtle variations in the tone are harder to see, but the texture adds a bold element of interest (see fig 16).

Figure 16. Photo 3 enlarged 300%.

Figure 17. Photo 4, actual size.

Figure 16. Photo 4, enlarged 300%.

The next series of photos were made with TS2. The amount of time the screen was over the paper was the variable. The first in the series, Photo 4, was exposed for 55 seconds, with the texture screen covering the paper for the entire exposure time (see fig 15). The texture is very apparent in the midtones, and subtler in the dark and light areas. The actual lines or threads that make up the texture are visible with the naked eye (see fig. 18).

Figure 19. Photo 5, actual size.

Figure 20. Photo 5, enlarged
300%.

Photo 5 was exposed for 35 seconds
with the texture screen and 20 seconds
more after removing the screen. The
texture blends into the photo because
the tiny spots of light blocked by the
screen were exposed for a short time
after the screen was removed (see
fig.19). Because of this, the texture is
barely visible in the very dark areas,
and the entire tone of the photo is
slightly darker (see fig 20).

Figure 21. Photo 6, actual size.

Figure 22. Photo 6, enlarged 300%.

The final photo in this series, Photo 6, was made by exposing it with the texture screen for 20 seconds, and without the screen for 35 seconds. The texture is now extremely subtle (see fig. 21). The delicate nature of this particular screen almost gives the impression of grain to the photo rather than a distinguishable texture. It is barely visible in the very dark areas (see fig 2
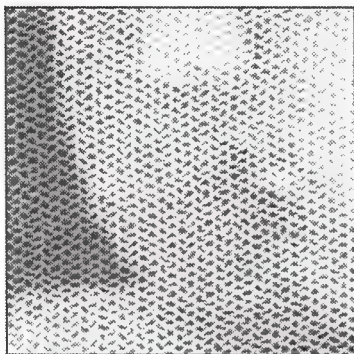
Figure 23. Photo 7, actual size.

Figure 24. Photo 7, enlarged
300%.

Moving into more extreme texture effects, Photo 7 was made with a single layer of the knit fabric used in Test 5 laid directly over the paper. It was exposed for 65 seconds. The weave of the fabric appears white and the spaces between let the photo show through. From a distance, you can make out the person in the photo, and it appears very light overall (see fig. 23). Up close, you can see that the spots are black and gray, but the photo takes on a more abstract nature due to the size of the texture (see fig 24).
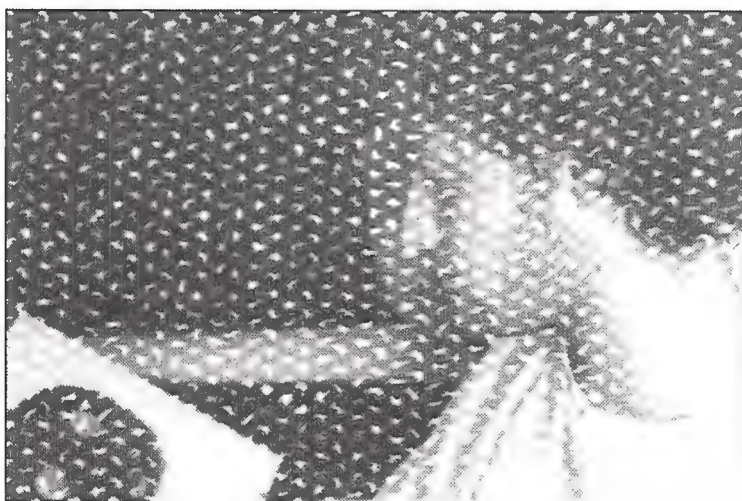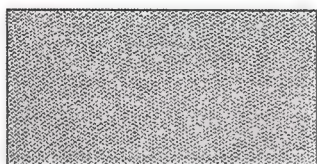
Figure 25. Photo 8, actual size.
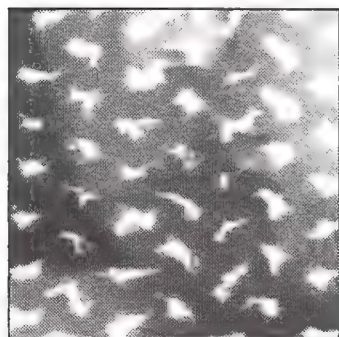

Figure 26. Texture screen, actual size.

Figure 27. Photo 8, enlarged 300%.

Photo 8 was made in a different manner, but also using the same black knit fabric From Test 5. This time, a texture screen single layer fabric was made first, reversing the way the texture will appear (see fig. 26). Then it was cut to fit into the negative carrier. This caused the texture to be enlarged. The photo only shows through the clear areas of the screen (the threads), and is completely blocked by the black spaces (see fig. 27). This enlarging of the texture creates a very dramatic texture effect. Although, the negative spaces are quite large, the photo is easier to read than the previous because it is not segmented as much as with the smaller, more intricate, texture (see fig. 25).

Considering the different materials that can be used, the different types of screens that can be produced, and the manners in which they can be used, there are infinite ways that texture screens can affect photographs. Within this small amount of research, I learned several things:

First, that experimentation is rewarding, and it is really the best way to understand the how's and why's of a particular process. Additionally, different screens would have been more appropriate for different subject matters, but for control purposes, I used the same photo for all of the relative experiments. Some minor frustrations were caused by scratches in the glass, which will first appear as thin white lines during the creation of the texture screen, and again when the same glass is placed over the photo paper when the photograph is made. Dust can also be a problem, especially on the larger screens, and for multiple layers of materials being used. These imperfections result in white specks in the final photo.

Texture screens are a relatively simple way to add interest to photographs and can be used by even the most novice photographers. Creating your own texture screens offers a greater challenge and results in more enjoyment and less capitol being utilized to complete the texture screen process. The screens that I have uncovered along with the developed techniques are ones that I will use in my future photography.

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Asymptotic Techniques in Enzyme Kinetics

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Introduction

As we live our lives day by day, many amazing scientific processes are occurring all around us. Some of these processes involve the reaction of enzymes. An enzyme is a substance that acts as a catalyst for chemical reactions. Beginning to understand these enzymes and the scientific processes that occur because of them is very difficult. We will introduce asymptotic techniques to investigate these processes. Asymptotic techniques in enzyme kinetics is a very in-depth subject and is why we will introduce the reader to a couple of asymptotic techniques used in enzyme kinetics. We will also introduce the reader to some elementary ideas that are needed before being able to fully understand the asymptotic techniques in enzyme kinetics. In order to understand enzyme kinetics, certain mathematical techniques will be used, including differential equations. Once an understanding of enzyme reactions is formed, we will then discuss a more advanced enzyme reaction called enzyme inhibition. The reader should be aware that this paper does not present original research. It does however present an expository survey and synthesis of the topic of enzyme kinetics based on the sources cited below.

Compartmental Diagrams

A very important concept that aids in the understanding of enzyme kinetics is compartmental analysis. Compartmental analysis is done by using compartmental diagrams. Compartmental diagrams are visual models of a physical, biological, or biochemical system or process. A compartmental diagram is very simple and consists of a few different elements. The first element is a compartment. A compartment represents an amount of homogenous material in a process and is labeled with a variable name. Another element in a compartmental diagram is an arrow. An arrow represents the flow of a sub-

stance into or out of a compartment and is labeled by an amount of variable change per unit of time. An example of a complete compartmental diagram that will be used later in the paper is below.
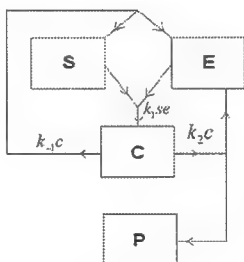
Now that we understand the elements of a compartmental diagram, we can apply the Compartmental Diagram Governing Principle. The principle states that the rate of change of substance in a compartment is equal to the inflow rate of the substance minus the outflow rate of the substance.

Rate of change in X = inflow rate - outflow rate

This principle allows the formation of a system of differential equations using a compartmental diagram. A differential equation can be formed for each compartment in a compartmental diagram.

Looking at compartmental diagrams from a physiological perspective reveals that variables represent the amounts of biological substances in a physiological system and the compartments represent these physiological systems. Using a compartmental diagram, we can answer a few questions that are fundamental to enzyme kinetics. We can understand the distribution of biological substances amongst various components of a physiological system. We can then, using the differential equations, understand how the distributions of biological substances change in a system.

The Law of Mass Action
The Law of Mass Action is the fundamental "law" of chemical reactions. This "law" helps us to find the rate at which two chemicals A and B react upon collision to form a product C (Keener, 1988).

$$A + B \xrightarrow{\quad K \quad} C$$
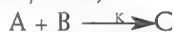
The "k" is the rate constant. It reflects the rapidity of the reactions. Its precise definition is given in the Law of Mass Action below. The next key step of this "law" is to find the rate of the reaction, which is the rate of accumulation of product,

$$\frac{d[C]}{dt}$$

where [C] denotes the concentration of the chemical C. The number of collisions per unit of time is proportional to the product of the concentrations of the two chemicals A and B. This rate depends on the energy of the collision and the geometrical shapes and sizes of the reactant molecules. This gives us (Keener, 1988),

$$\frac{d[C]}{dt} = k[A][B]$$

Biochemical reactions are typically bi-directional. Reverse reactions are common in every reaction but are not looked at if they are slower than the forward reaction. The forward and backward reactions are shown below (Keener, 1988).

$$A + B \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} C$$
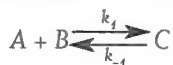
We can find the rate of change for the chemical by using a compartmental diagram. The compartmental diagram shows the rate of inflow and outflow of a chemical. For example, we find the rate of change for [C] by the differential equation (Keener, 1988).

$$\frac{d[C]}{dt} = k[A][B] - k_-[C]$$

A fundamental problem is to calculate steady state or equilibrium quantities. As a prelude to what follows, we want to find the equilibrium concentration of [C]. Equilibrium is a state when the concentrations of chemicals are no longer changing. In equilibrium, the rate of accumulation of the product chemical C is equal to zero. Then we know that the rate of inflow minus the rate of outflow is also equal to zero (Keener, 1988).

$$k_-[C] - k_+[A][B] = 0 \qquad \text{(eq. 1)}$$

We want to solve for the equilibrium concentration of chemical C. We know that in a closed system, where no other reactions are taking place, the concentration of chemical A added to the concentration of chemical C is equal to a constant Ao. This is known as the conservation of matter equation, [A] = Ao - [C]. After several substitutions on (eq. 1), we find that the equilibrium concentration of C is equal to (eq. 2).

$$k_-[C] - k_+[B]([A_0 - [C]) = 0$$

$$[C]_{eq} = \frac{\frac{k+}{k_-} A_0[B]_{eq}}{1 + \frac{k+}{k_-} [B]_{eq}}$$

(eq. 2)

$$[C]_{eq} = \frac{A_0[B]_{eq}}{\frac{k+}{k_-} + [B]_{eq}}$$

$$[C]_{eq} = \frac{A_0[B]_{eq}}{K_{eq} + [B]_{eq}} \qquad \frac{K_{eq}}{[A]_{eq}} = \frac{k+}{k_-}$$

Likewise, $[C]_{eq}$ could be expressed in terms of

$K_{eq} = \frac{k+}{k_-}$ is called the equilibrium constant. This constant relates to the relative preference for the chemicals to be in the combined state C. This constant has units of concentration (Keener, 1988). Please note that the Law of Mass Action cannot be used in all situations, because not all chemical reactions are known in such detail. The reactions that follow the Law of Mass Action are called elementary reactions. We will discuss other methods of investigating what is occurring in biochemical reactions (Keener, 1988).

Enzyme Kinetics

It is very important to understand what takes place in an enzyme reaction and what can be obtained from analyzing the reaction to use in determining other factors. Before an explanation of enzyme reactions can be conveyed, some background information on enzymes must be given. An enzyme is a substance that acts as a catalyst for some chemical reaction. They act on other molecules called substrates, helping to convert them into products. The enzymes themselves are not changed by the reaction. Enzymes work by lowering the "free energy of activation" for the given reaction (Keener, 1988).

Enzyme reactions do not follow the Law of Mass Action directly. If this were the case, theory would predict the following chemical reaction scheme,

$$S + E \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} C$$
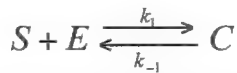
where the enzyme E would act on the substrate S to form a complex C, but it has been shown that this is *not* the case. Instead, the Michaelis-Menten Model (1913) will be used to describe the enzyme reaction (Keener, 1988). The idea of the Michaelis-Menten Model is a two-step process. Step one is where the enzyme E first converts the substrate S into a complex C. Then, in step two, the complex C is broken down into a product P, releasing the enzyme E in the process (Keener, 1988).

The chemical reaction scheme obtained from this idea is as follows.

$$S + E \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} C \overset{k_2}{\longrightarrow} P + E$$
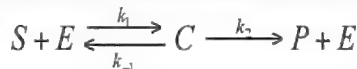
Note that k2 is the dissociation constant for this chemical reaction. The dissociation constant is the rate at which the complex breaks up into product and enzyme (Keener, 1988).

From this chemical reaction scheme, we can form a compartmental diagram, which was described previously. The substrate, enzyme, complex, and product will all be compartments in the diagram, and the rate constants k1, k-1, and k2, along with the concentrations of each of the substances, will be used to show the inflow and outflow rates to the compartments. The compartmental diagram is shown below.
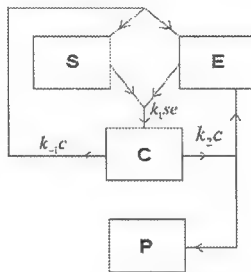
From this compartmental diagram, as described earlier, we can derive the following differential equations. Note that instead of using [C] to denote a chemical's concentration, we are now using lower case letters. For example [C] =

$$\frac{ds}{dt} = k_{-1}c - k_1 se \qquad \text{(eq. 3)}$$

$$\frac{dp}{dt} = k_2 c \qquad \text{(eq. 4)}$$

$$\frac{de}{dt} = (k_{-1} + k_2)c - k_{-1}se \qquad \text{(eq. 5)}$$

$$\frac{dc}{dt} = k_1 se - (k_{-1} + k_2)c \qquad \text{(eq. 6)}$$

Please note that a differential equation has been derived for each of the compartments. For example, the differential equation formed for the compartment of the substrate S is obtained by taking the inflow rate into the compartment, k-1c, minus the outflow rate from the compartment, k1se, to get the desired result of k-1c-k1se (eq. 3). The remaining differential equations are obtained in a similar fashion. These differential equations will be used further in the following discussions dealing with enzyme reactions.

The Equilibrium Approximation

One of the major problems in enzyme kinetics is finding the rate of formation of product. In other words, we want to solve for

$$V = \frac{dp}{dt} = k_2 c$$

The Equilibrium Approximation was developed by Michaelis and Menten in 1913. They developed this approximation in order to approximate the rate of formation of product in an enzyme reaction, thus solving one of the major problems in enzyme kinetics. Their approximation is obtained by assuming that the substrate is in instantaneous equilibrium with the complex (Keener, 1988). In other words, the rate of change of substrate is equal to zero. Using the differential equations we found earlier, we stated that

$$\frac{ds}{dt} = k_{-1}c - k_1 se. \qquad\qquad \text{(eq. 3)}$$

Using this equation for the rate of change of substrate and combining it with our assumption, we conclude that,

$$\frac{ds}{dt} = 0$$

$$k_{-1}c - k_1 se = 0$$

$$k_{-1}c = k_1 se.$$

Since we have stated that there is a conservation of enzyme, we know that , where is the initial enzyme concentration. We will now be able to substitute that into the equations below and thus solve for c.

$$\frac{k_{-1}}{k_1}c = se \qquad \text{Let,} \qquad k_s = \frac{k_{-1}}{k_1}$$

$$k_s c = se$$

So, by substitution

$$k_s c = s(e_o - c)$$

$$k_s c = se_o - sc$$

$$sc + k_s c = se_o$$

$$c(k_s + s) = se_o.$$

Thus,

$$c = \frac{se_o}{k_s + s}.$$

Now that we have an expression for c, we can substitute that into our original differential equation (eq. 4)

$$V = \frac{dp}{dt} = k_2 c$$

and get

$$V = \frac{k_2 e_0 s}{k_s + s}. \qquad \text{(eq. 7)}$$

Thus, we have our expression for the reaction velocity, or rate of change of product in an enzyme reaction (Keener, 1988). When there is a formula to describe a situation, one must be interested in certain special cases. The following observations can be made regarding the rate of change of product in an enzyme reaction.

Observation 1: The maximum reaction velocity is a special case that one may be interested in. The maximum reaction velocity occurs when the concentration of the complex is largest. This can also be thought of as when the entire enzyme is complexed with the substrate. Mathematically, that can be thought of as $c = e_0$(Keener, 1988).

Thus, it is true that

$$V_{max} = \frac{dp}{dt} = k_2 c = k_2 e_0. \qquad \text{(eq. 8)}$$

Substituting our expression for the maximum reaction velocity into our expression for V above (eq. 7), we conclude that

$$V = \frac{V_{max} s}{k_s + s}.$$

Observation 2: For large substrate concentrations, in can be shown that the reaction rate saturates to V_{max} (Keener, 1988).

This can be shown as follows,

$$V = \frac{V_{max} s}{k_s + s}$$

$$= \frac{s}{s} \left(\frac{V_{max}}{\frac{k_s}{s} + 1} \right) = \frac{V_{max}}{\frac{k_s}{s} + 1}$$

Note: $\dfrac{k_s}{s} \approx 0$ because our assumption is that s is very large.

Observation 3: When $s = k_s$, it can be shown that

$$V = \frac{V_{max}k_s}{2k_s}$$
$$= \frac{V_{max}}{2}.$$

(eq. 9)

Thus, the reaction velocity is half that of the maximum reaction velocity (Keener, 1988).

One must be careful to remember that the above expression for V (eq. 9) is just an approximation. If it were always true, then it can be shown that the substrate would not be used up, and product would not be formed (Keener, 1988). After investigating this approximation technique, it is also important to remember that there may be other ways to approximate the reaction velocity V. We next investigate a second approximation technique used for approximating the reaction velocity of an enzyme reaction.

Quasi-Steady-State Approximation

An alternate analysis of enzyme reactions is the Quasi-Steady-State Approximation. The idea behind the Quasi-Steady-State Approximation is to first use nondimensionalization to replace the rates of s, e, c, and p. Next, apply the Briggs-Haldane Assumption, which states that the rate of formation and the rate of breakdown of the complex are equal (Keener, 1988).

At the present time the independent variables are: s, c and the parameters are: k1, k-1, k2. The idea of nondimensionalization is to consider the new dimensionless variables:

$$\sigma := \frac{s}{s_o} \qquad\qquad x := \frac{c}{e_o} \qquad\qquad \tau := k_1 e_o t \ .$$

Recall that so and eo are initial amounts of substrate and enzyme.
We are also going to replace the parameters with these new variables:

$$\alpha := \frac{k_{-1}}{k_1 s_o} \qquad\qquad \varepsilon := \frac{e_o}{s_o} \qquad\qquad \kappa := \frac{k_{-1} + k_2}{k_1 s_o} \ .$$

Now that we have our new variables, the first thing to do is rewrite the differential rate equations in terms of the new variables:

ds/dt into $\qquad\qquad \frac{d\sigma}{d\tau} = -\sigma + x(\sigma + \alpha)$ (eq. 10)

and dc/dt into: $\qquad\qquad \varepsilon\frac{dx}{d\tau} = \sigma - x(\sigma - \kappa)$ (eq. 11)

Since e is small, we regard $\qquad \varepsilon\frac{dx}{d\tau} \approx 0$

The Quasi-Steady-State Approximation then concludes,

$$\frac{d\sigma}{d\tau} = -\frac{\sigma q}{\sigma + \kappa} \quad where \quad q = \frac{k_2}{k_1 s_0} \qquad \text{(eq. 12)}$$

which describes the rate of uptake of the substrates (Keener, 1988). Then, bringing all this information together, we can combine what was known about product formation beforehand and our conclusions from the Quasi-Steady-State Approximation.

Recall that by (eq. 3,4), $V = \frac{dp}{dt} = \frac{-ds}{dt} = -s_o k_1 e_o \frac{d\sigma}{d\tau}$.   (eq. 13)

Now by reverse substitution into (eq. 13) using (eq.12) we get:

$$V = \frac{dp}{dt} = \frac{-ds}{dt} = -s_o k_1 e_o \left(\frac{-q\sigma}{\sigma + \kappa}\right)$$

which can be rewritten as:
$$= \frac{k_2 e_o s}{s + \kappa s_o},$$

$$V = \frac{V_{max} s}{s + k_m}$$

where by (eq. 8), $V_{max} = k_2 e_0$ and $k_m = \kappa s_o = \frac{k_{-1} + k_2}{k_1}$.

When comparing the Equilibrium Approximation and the Quasi-Steady-State Approximation, we can see that these two reaction schemes are similar, but not the same. Differences include: the Equilibrium Approximation is simple to apply but has less scope, while the Quasi-Steady-State Approximation uses nondimensionalization, which is more complex, but applies to a greater scope. Because of its larger scope, most present-day descriptions of enzyme reaction use the Quasi-Steady-State Approximation There are other reaction schemes where the estimates of V are not quite as similar.

Enzyme Inhibition

We have looked at some asymptotic techniques for studying enzyme kinetics. Let us now turn our attention to enzyme inhibition. Enzyme inhibitors are substances that inhibit the catalytic action of an enzyme (Keener, 1988). They slow down or decrease enzyme activity to zero. Basically, an inhibitor stops the enzyme from helping the chemical reaction to occur. Some examples of inhibitors would be nerve gas and cyanide. Each of these are irre-

versible inhibitors or catalytic poisons that reverse the activity of life supporting enzymes.

To understand enzyme inhibition, we must first understand the structure of an enzyme. An enzyme is typically a large protein molecule to which other molecules can bind. Molecules can bind to either the active site or the allosteric site on an enzyme. Active sites are sites on an enzyme where substrate can bind to form complex. However, when an inhibitor is bound to the active site it is called competitive inhibition. In this situation an enzyme actually competes with an inhibitor to bind to the active site. When the inhibitor wins this competition there is a less complex formed. There is one reaction forming complex C1 and another using the inhibitor to form C2 (Keener, 1988).
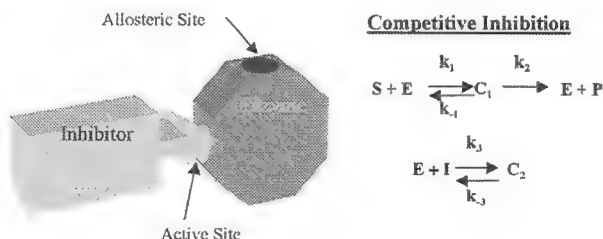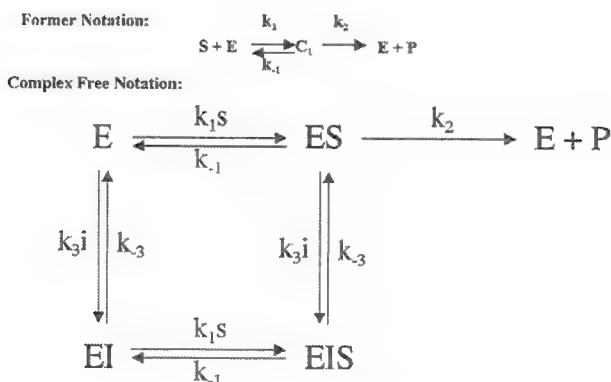

Allosteric sites are secondary sites on an enzyme that regulate the catalytic activity of an enzyme. When an inhibitor is bound to the allosteric site it is called allosteric inhibition. An inhibitor may be bound to the allosteric site at the same time as a substrate is bound to the active site. This leaves a very complicated reaction scheme. We have the same two reactions that we saw in competitive inhibition along with two more because of the possibility of complex C2 binding with substrate to form complex C3 and the possibility of complex C1 binding with an inhibitor to form complex C3 (Keener, 1988).
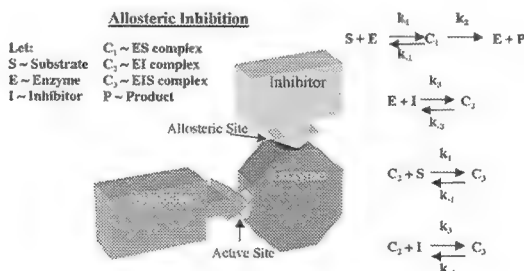

For allosteric inhibition, it is easier to use "Complex Free Reaction Notation." In this notation, one substance is not explicitly written but is implicitly present. For example in the following reaction the substrate is repre-

sented with an S. In the new notation, the substrate S is implied. Also, the complex C1 is represented as ES and the concentration of S is with the rate constant k1.

Former Notation:

$$S + E \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} C_1 \xrightarrow{k_2} E + P$$

Complex Free Notation:

$$E \underset{k_{-1}}{\overset{k_1 s}{\rightleftharpoons}} ES \xrightarrow{k_2} E + P$$

$$k_3 i \Big\updownarrow k_{-3} \qquad k_3 i \Big\updownarrow k_{-3}$$

$$EI \underset{k_{-1}}{\overset{k_1 s}{\rightleftharpoons}} EIS$$

Applying the new notation to all four possible reactions yields a very complicated set of reactions. From this reaction scheme we can then create a compartmental diagram using the same method as previously discussed.

Let:
X = ES
Y = EI
Z = EIS
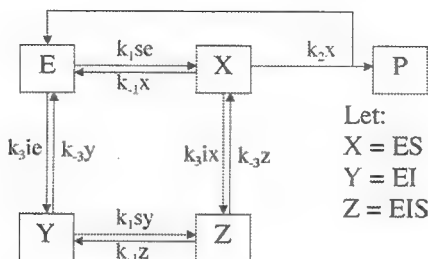
A system of differential equations can be formed from the compartmental diagram. From here we can then use one of the many asymptotic techniques to understand the fundamental questions asked about enzyme kinetics.

Conclusion

As you can see, asymptotic techniques in enzyme kinetics can get quite complex. However, these techniques give us vital information about the model without having to solve the differential equation directly.

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Alcohol and Other Drug Perceptions Survey

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Literature Review
National

Each year, more than 100,000 people die in our country from alcohol and other drug (AOD) related causes. Some estimates show that AOD related problems cost taxpayers more than $294 billion each year for preventable health care, extra law enforcement, automobile accidents, crime, and lost productivity (Bush, 2001). Not only does AOD abuse effect the well being of our country; it also has a great effect on our families. One in four of our nation's children are exposed to alcoholism or alcohol abuse in their families before the age of 18 (Bush, 2001). Extensive research has shown that AOD related problems often lead to other serious issues. These may include health, legal, family, personal, and business related difficulties.

Colleges

Several studies of AOD abuse at the college level have found additional campus-related problems. These include poor academic achievements, disrupted attendance, risky sexual behaviors, violent behaviors, and other illegal activities (Wechsler, Lee, Kuo, Seibring, Nelson, & Lee, 2002). Dr. Henry Wechsler, principle investigator for the Harvard School of Public Health College Alcohol Study (CAS), has done extensive research on the drinking behaviors of college students. Binge drinking and the resulting consequences has been recognized as the number one public health problem affecting college students since the 1990's (Wechsler et. al, 2002). The CAS has defined *binge drinking* as the consumption of five or more drinks during one sitting in the past two weeks for males, and four or more dinks for females. Such behaviors place the drinker, as well as others, at an increased risk of alcohol related problems (Wechsler & Nelson, 2001).

Specifically, some effects that student drinkers may experience include

educational, social, and health problems (Wechsler, Nelson, & Weitzman, 2000). Although widely publicized, deaths due to alcohol consumption are relatively low; however, most large colleges report overdose admissions in emergency rooms and student health centers due to alcohol poisoning. In one CAS survey, 0.6 percent of students reported receiving treatment for alcohol overdose; while small on the individual campus scale, nationally this would include some 30,000 college students each year. In the same study, roughly 12 percent of respondents reported an injury resulting from alcohol use; one in twenty of these injuries required medical attention. Academic performance also suffers - half of binge drinkers report missing at least one class due to the consequences of alcohol use. More than one-third of these drinkers report falling behind in their academic studies. Binge drinkers are also more likely to report lower grades when compared to non-bingers (Wechsler, Nelson, & Weitzman, 2000).

Non-binging peers may experience second-hand effects of AOD use such as insults and arguments, vandalism, physical assaults, and unwanted sexual advances. One in eight of non-binge drinking students reported being the victim of physical assault or having their property vandalized as the result of another student's alcohol use (Wechsler, Nelson, & Weitzman, 2000). In the 2001 CAS, the most frequently experienced second-hand effects reported by non-bingers included having their study/sleep interrupted (60%), having to care for a drunken student (48%), and being insulted or humiliated (29%). The rates of such second-hand effects were higher for respondents living in fraternity/sorority houses than for those living in residence halls (Wechsler, et al., 2001).

UW-Stout

Beginning in 1999, the Chancellor's Coalition Addressing Problem Drinking (CCAPD) conducted several surveys to learn more about the AOD environment at UW-Stout. The measure used was the Core Student AOD Use Survey, a survey designed by the Core Institute at Southern Illinois University-Carbondale. In May of 2000, the Core survey was administered to 604 UW-Stout students. These results were compared to national averages from 64 two and four-year colleges in classroom settings. The results indicated that Stout was at or above the national average for most AOD related problems. Wechsler's studies have shown that binge drinking varies from campus to campus across the country. The lowest rate reported was only 1% of the student population, whereas the highest rate was 70% of students binge drink. The CORE results indicated that nearly 71% of Stout students surveyed would be categorized as binge drinkers by Wechsler's terms, putting Stout at the higher extreme. The CORE results strongly suggest that an AOD problem does exist at Stout.

In May of 2000, the CCAPD interviewed a small group of administrators and student leaders to gather their perceptions and recommendations related to AOD abuse at Stout. This group included the Provost, Vice Chancellor,

the Deans, Assistant Chancellor for University Development, Director of Student Life Services, Director of Residence Life, Director of University Relations, Director of Enrollment Services, Director of the Student Center, President of the Stout Student Association, and the Inter-Greek Counsel President. In agreement with the Core survey, the interviewees perceived an AOD related problem at Stout. These participants were identified as the top decision-makers on campus. In addition, their suggestion for prevention programming was a key factor in the activities undertaken by the CCAPD.

In order to evaluate the campus AOD problem further, the CCAPD approached the Spring, 2002 Program Evaluation 2 class for assistance. The class met with Allen Ebel, the Coalition chair, receiving background information and study questions to be addressed. As a result, the class reviewed the history of AOD use and abuse at the national, collegiate, and local (UW-Stout) level. From this information, the above campus leader perceptions survey was revised, including additional questions for comparisons and asking for recommendations regarding solutions. The targeted participants of these surveys were the faculty/staff and the students of the University at large. The purpose was to gather information about the perceptions of the AOD environment at UW-Stout, allowing for comparisons within and between these groups.

Methods
Sampling
Using an email address book, the first student on every page was selected, totaling 1,463 students. In a similar fashion, faculty/staff were selected from the 2001-2002 *UW-Stout Informational Directory*. The first five names under each heading in the Department and Services section were selected. This method yielded 217 employees. If after one week there were not adequate responses, a follow-up email was sent to remind those who may have forgotten.
Participants
Of the 49 student respondents, 53.1% were female. Ages ranged from 18 to 50 years with an average age of 22.1 (sd = 4.8) years. The majority of student respondents (85.7%) were enrolled full-time. The academic level reported was slightly skewed; 12.2% were freshmen, an equal amount of respondents (24.4%) were sophomores and juniors, 32.7% were seniors, and 4.1% of respondents were graduate students. Of the respondents, 10.2% reported belonging to a fraternity/sorority and an equal proportion were involved with student government, 8.2% belonged to religious groups, 4.1% reported being athletes, 30.6% belonged to other clubs (including The Institute of Packaging Professionals, Academic Honor Society, Blue Devil Productions, and Psi Chi) and 16.3% belonged to other groups (including NRHH, Stoutonia, GDA, and Symphonic Singers). A full 44.9% of student respondents indicated that they do not belong to any student clubs or groups. 36.7 % of respondents indicated that they belonged to one club/group, 8.2% belonged to

two clubs/groups, 2.0% belonged to three clubs/groups, and 8.2% belonged to four clubs/groups.

Of the 52 faculty/staff respondents, 55.8% were male. Ages ranged from 24 to 66 with an average age of 45.5 (sd = 10.4). Of the respondents, 63.5% indicated that they were part of the Academic and Student Life Services (ASLS) with the remaining 36.5% being part of the Academic and Student Affairs (ASA). None of the respondents indicated that they were part of the Chancellor's Office. In-class instructors made up 71.2% of the respondents. Almost one out of five (19.2%) of faculty/staff respondents indicated that they were part of Administration. 11.5% held Residence Hall positions while 7.7% were part of Mental Health Services. None of the respondents indicated that they were part of AOD Services, Health Services, or Law Enforcement. Three of the respondents (5.8%) reported belonging to two positions and one respondent (1.9%) reported belonging to three positions.
*Materials*

Two electronic based surveys were designed to gather information about perceptions of AOD use at the University of Wisconsin-Stout. One survey was designed for students while the other survey was designed for faculty and staff. The surveys were based off the guide from the 2000 interview conducted by the CCAPD. Additional questions were included to address specific areas of interest expressed by Allen Ebel. (see Appendix).

Results
Description of the AOD Environment at UW-Stout

All faculty/staff and students were asked to Briefly describe the AOD environment at UW-Stout.

Figure 1: Description of the AOD Environment
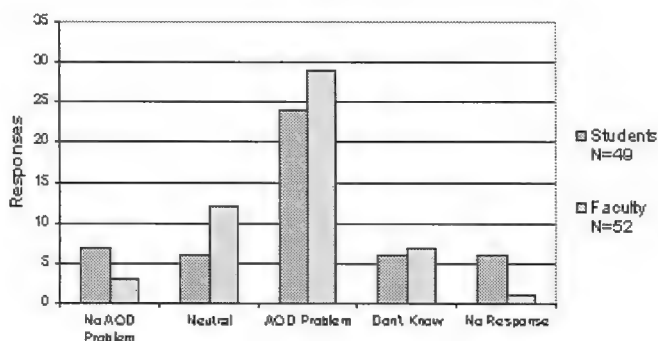
Similarities
- Neither students nor faculty/staff who did not describe a problem indicated a reduction in AOD use in the UW-Stout environment.
- Both students and faculty/staff who were neutral in their description cited various levels of use and similarity to other universities.
- A majority of both groups described the current AOD environment as problematic.
- Both groups most frequently cited prevalent alcohol use/abuse.
- Both groups cited prevalent drug use/abuse, cultural/social norms, availability, accessibility, and underage drinking as themes in the problem environment.
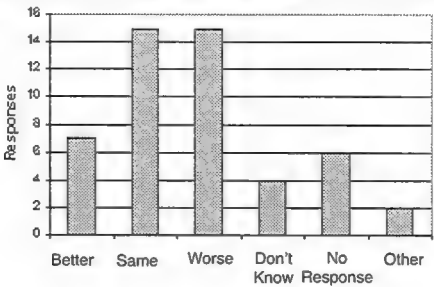
Differences
- More faculty/staff than students provided neutral descriptions of the AOD environment at UW-Stout.
- More faculty/staff than students described a problem in the AOD environment at UW-Stout.

Comparisons of the Current AOD Environment at UW-Stout

Faculty/staff and students were asked to make comparisons of the current AOD environment at UW-Stout in reference to either their high school or to UW-Stout five years ago.
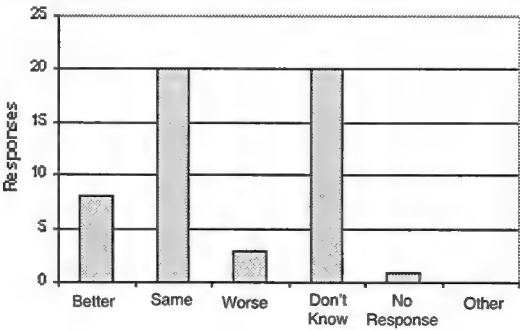
Students

Figure 1: Student Comparisons of Current Environment at UW-Stout vs. Their High School

Faculty/Staff

Figure 2: Faculty/Staff Comparisons of Current Environment at UW-Stout vs. Five Years Ago

Perception of AOD-Related Problems at UW-Stout

     All faculty/staff and students were asked Do you perceive any AOD related problems at UW-Stout?

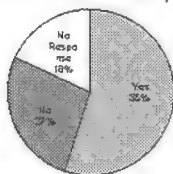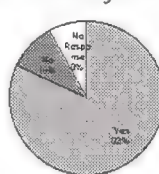*Figure 3 Student Perceptions*   *Figure 4 Faculty Perceptions*

Similarities
- A majority of both group perceived the current AOD environment as problematic.

Differences
- More faculty/staff than students perceived the current AOD environment as problematic.
- More students than faculty/staff did not respond.

Causative Factors

     Only those faculty/staff and students that perceived an AOD-related problem at UW-Stout were asked the following question: What might be the causes of AOD-related problems?

Figure 5: Causative Factors of AOD Related Problems
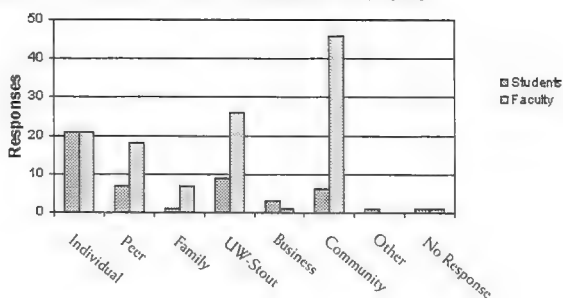
Similarities
- Both students and faculty/staff identified individual, peer, UW-Stout, and community-related factors as the major causes of the AOD problem at UW-Stout.
- In individual factors, both groups identified boredom.
- In peer factors, both groups identified peer pressure.
- In UW-Stout factors, both groups identified University tradition, lack of non-AOD related activities, and a lack of administrative involvement/response.
- In community factors, both groups identified a lack of non-AOD related activities, availability, and cultural/social influences.

- Both students and faculty/staff cited parental history as a family factor.

Differences

- Faculty/staff viewed community factors as the main cause whereas students viewed individual factors as the main cause of AOD-Related problems.
- Faculty/staff cited peer and UW-Stout factors more often than students did.
- In terms of community factors as a contributor to AOD related problems, faculty/staff overwhelmingly cited cultural/social influences whereas students cited a lack of non-AOD related activities.

Impact on UW-Stout

Only those faculty/staff and students that did perceive an AOD-related problem were asked the following: *How might AOD-related problems impact the educational and/or student development missions at UW-Stout?*

Figure 6: Impact of AOD Related Problems on UW-Stout
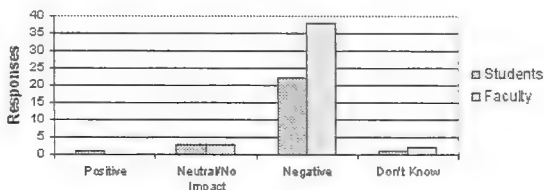
Note. Only those responses with negative impacts were coded.

Figure 7: Negative Impacts of AOD Related Problems
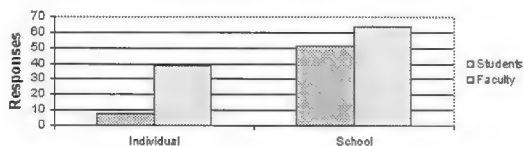
Similarities

- A majority of both groups perceived a negative impact of AOD related problems on the educational and/or student development missions at UW-Stout.
- Both groups cited health problems and intoxication in class as individual impacts.
- Both groups cited poor performance, lowered standards at UW-Stout, a bad reputation of UW-Stout, and disturbing or interfering with others as school impacts.

Differences

- Faculty/staff cited more serious health problems than students did.

- Faculty/staff cited a weakened educational mission under school impacts.

Reductive Actions

   Although identification of a problem is important, offering possible solutions is also imperative. Only those faculty/staff and students that did perceive an AOD-related problem at UW-Stout were asked the following questions:

- *What might you personally do to reduce AOD-related problems at UW-Stout?*
- *What might the University do to reduce AOD-related problems at UW-Stout?*
- *What might the surrounding community do to reduce AOD-related problems at UW-Stout?*
- *How could the people in your groups/clubs contribute to the improvement of the campus environment as it relates to AOD abuse? (Only students were asked this question)*

Figure 8: Possible Actions to Reduce AOD Related Problems
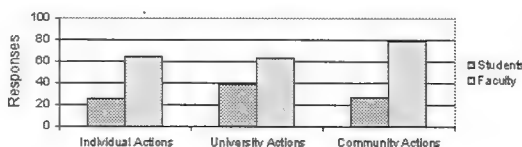
Similarities

- Both groups cited education/information as individual actions.
- Both groups cited education/information and enforcement as University actions that may be taken.
- Both groups identified enforcement, more non-AOD related activities, transportation services, reducing availability, and education/information as community actions that may be taken.

Differences

- Faculty/staff cited community actions most often whereas students cited university actions most often as reductive measures.

Preventative Factors

   Only those faculty/staff and students that did not perceive a problem were asked the following: *What factors might be preventing any AOD related problems at UW-Stout?*

Figure 9: Factors that May Prevent AOD Related Problems
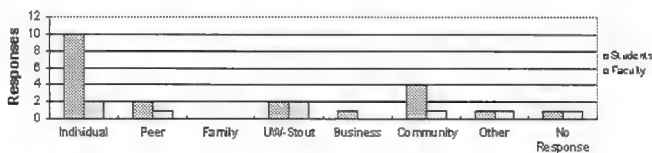
Similarities
- Both groups cited student efforts as individual factors that may prevent AOD related problems at UW-Stout.
- Both groups identified supportive friends as peer-related preventative factors.
- Neither faculty/staff or students cited any family related preventative factors.
- Both groups cited the availability of non-AOD related activities at UW-Stout as preventative factors.

Differences
- Students cited individual and community factors as possible preventatives more frequently than faculty/staff.

Preventative Actions

Only faculty/staff and students that did not perceive any AOD-related problem at UW-Stout were asked the following questions:
- *What might you personally do to further prevent any AOD-related problems at UW-Stout?*
- *What might the University do to further prevent any AOD-related problems at UW-Stout?*
- *What might the surrounding community do to further prevent any AOD-related problems at UW-Stout?*

Figure 10: Possible Actions that May Prevent AOD Related Problems
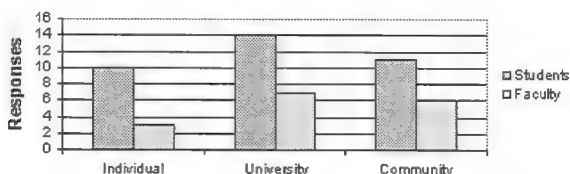
Similarities
- Both groups cited university actions most frequently as possible pre ventive measures.
- Both groups identified the availability of more non-AOD related activ ities, education/information, and offering/provide counseling, treat ment, and social support as University actions.
- Both groups described the availability of more non-AOD related activ ities and a change in law, specifically enforcement as community actions.

Differences
- Students provided more preventive measures than faculty/staff. However, this is not surprising as many more students were asked to respond to this question than faculty/staff.

Discussion

     A majority of both students and faculty/staff described the AOD environment at UW-Stout as problematic. When students were asked to compare the AOD environment at Stout to that of their high school, the majority felt that it was the same or worse. When faculty/staff were asked to compare the AOD environment at Stout to that of five years ago, the majority felt that it was either the same or they did not know. These results suggest several possible conclusions. Possibilities include that a large amount of the faculty/staff surveyed were either new or possibly disconnected to student life. Another possible conclusion is that the AOD environment at UW-Stout has not changed over the last five years. Still another possible conclusion is that the CCAPD needs to improve its dissemination of information about AOD related issues at UW-Stout.

     The majority of both students and faculty/staff perceived an AOD related problem at UW-Stout. However, a considerably larger amount of faculty/staff perceived an AOD related problem in comparison to students. Employees most frequently identify the community and UW-Stout as the causative factors of this AOD problem. These factors tended to be externally focused - for example, traditional, cultural, and social factors. Students, on the other hand, most frequently identified individual factors as the cause of AOD related problems. These factors tended to be more internally focused. For example, boredom, fitting in, and relieving stress were all cited. Both students and faculty/staff related that a lack of non-AOD related activities is a causative factor of this problem.

     The majority of both students and faculty/staff identified that AOD related problems have a negative impact on the educational and student development missions at UW-Stout. However, students were less likely to identify adverse individual impacts of AOD related problems. Faculty/staff and students that did perceive an AOD related problem at UW-Stout were asked what they personally could do to reduce the AOD problem and what the University and surrounding community could do. The three most common themes were (1) to provide more educational information, (2) more enforcement, and (3) more non-AOD related activities. Students identified a need for more enforcement by both the University and the community as the number one action to reduce the AOD related problem. Students also mentioned there is a need for more non-AOD related activities. Faculty/staff identified a need for more educational information as the number one reductive action to reduce AOD related problems. In addition, employees identified a need for more enforcement by both the University and the community.

     Students and faculty /staff that did not perceive a problem were asked what factors might be preventing AOD related problems at UW-Stout. It should be noted that more students than faculty/staff did not perceive an AOD related problem, this may skew the results somewhat. However, students per-

ceived individual students' efforts as the number one factor in preventing AOD related problems. Once again, students were identifying internal factors related to this problem. Those individuals who did not perceive an AOD related problem at UW-Stout were asked what they personally could do to further prevent any AOD problems and what the University and surrounding community could do. At the individual level, the students reported more internally focused preventative actions - for example, making good decisions, being responsible, and role modeling. However, faculty/staff reported more externally focused preventative actions - for example, providing education to the students. At the University and community level, both students and faculty/staff reported a need for more non-AOD related activities, more enforcement, and more educational informational as the most important preventative actions.

Limits

There are potential limitations to the present research. The overall response rate to the survey was poor; the student response was about three percent while the faculty response rate was about 20 percent. The timing of the surveys was another limitation to this study. The surveys were distributed at the end of the semester. At this time of the year students and faculty are dealing with other exams, several other distributed surveys distributed and graduation is approaching. There are other possible effects of the current survey. For example, previous AOD studies, open ended verse close ended questions, assuming the population reads and responds to their e-mail and the anticipation of summer break could produce confounding results. There are also time limitations of the present study. There was a limited time frame on the design and development of the instrument, and the collection/analysis of the data.

Suggested Implications

The following section refers to implications and possible actions that could be taken to address the AOD-related problem at UW-Stout identified by both students and faculty/staff. These views reflect the views, perceptions, and opinions of the researchers and do not necessarily reflect the views or opinions of the University or any of its faculty/staff.

The major implication of this study is that put simply, do something to address the AOD related problem at UW-Stout. This study provided results similar to other studies that have indicated a problem exists. A majority of people surveyed perceived a problem; therefore, it must be assumed that there is one.

The results have suggested several possible actions that could be taken to address the AOD related problem at UW-Stout. First and foremost, there should be a coordinated response to AOD related issues. This involves multiple stakeholders at multiple levels throughout the entire process. Not only seeking and incorporating input from several parties (for example, community, university, faculty, business, family, peer groups) but also expecting commitment and action from them. This might include possible changes and additions to poli-

cies, procedures, and actions on an individual, group, and system level.

The researchers suggest that the coordinated response involve a three-prong approach. First, increasing education and awareness not only for students and their families, but also the faculty, administration, community, and area businesses. The process of change is a learning process. This education might include the physical and psychological costs associated with AOD use/abuse. Additionally, possible legal, financial, academic, social, and other consequences would be emphasized. Another area to be addressed is the readily available treatment options for those in need. In addition, positive alternatives to AOD related activities would be made widely known.

The second prong to the approach would be the availability of non-AOD related activities. This would include better, safer alternatives to AOD-related opportunities. These would be developed directly from the input of the student body. What is available at present and in the future needs to be widely disseminated to the students at large. Other related possibilities include removal or restriction of AOD related advertising in the Stoutonia, free or reduced advertising rates for non-AOD related activities, or a combination of the two.

The third prong is enforcement. There may be existing policies, standards, and laws dealing with AOD related issues that are not be consistently or regularly enforced. For policies and laws to be effective, there needs to be continuous and immediate consequences for AOD related infractions. This is true not only in the community, but also in the classroom and dormitory of the University. Additionally, making the University at-large and the community more aware of these standards and practices would provide a ripple effect. Small but consistent actions (for example, fines, treatment, academic sanctions, and incarceration) would resonate across all levels. However, consequences should not be only about punitive measures. There should be some flexibility so those in need would receive any additional treatment or counseling services.

These actions, provided in a coordinated, thoughtful, and methodical manner, could produce a synergistic effort to help change the cultural and traditional norms that have persisted for many years. The social and societal standards that encourage AOD related abuse are likely to take time, persistent efforts, and patience to change. These suggestions are but a few of the many small steps that will need to be taken to reduce AOD problems on the university of Wisconsin-Stout campus.

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Does the Gender of Initial Contact Affect Premature Termination of Therapy?

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Introduction

Gender plays an obvious role in the therapeutic process. The gender piece can be examined from a client stance or that of a therapist stance. There has been descriptive research conducted on gender differences as it relates to marriage and family therapy (Werner-Wilson, et al, 1999). However, there are few studies available examining the role that gender plays in the initial contact at the beginning of therapy and what impact that has on the outcome of therapy.

In this study, the authors are interested in determining if there is any link or relationship between the gender of the person that makes the initial contact for couples or family therapy and how many sessions are attended. The interest for this study developed for two reasons. First, there is a lack of research on gender, initial contact, and length of sessions completed. Second, the authors are inclined to believe that if men make the initial contact, more sessions will be attended than if men make the first contact. This assumption arises from thinking that men will then feel more invested in the therapy process, and thus attend more sessions.

The purpose of this exploratory study is to examine if families or couples in which the male member of the family makes the initial contact to set up the first appointment will complete more therapy sessions than families or couples in which a female member makes the initial contact.

Literature Review

The authors were unable to find research pertaining to the gender of the client making initial contact to arrange therapy. There is some literature having to do with premature termination. Clients who prematurely terminate are found to have poor alliances with therapists than completers, and their therapists display less warmth and friendliness than that exhibited to therapy completers (Chisholm, 1998). Taller (2001) finds that clients who pay for ther-

apy are twice as likely to terminate after one session as clients who do not. Premature termination has been associated with the therapist's age, specialty, agency, degree, and the age of clients (Christensen, 2002).

In a study of children's premature termination of therapy (Venable & Thompson, 1998), characteristics of the caretakers were found to affect the termination of children's therapy. If the caretaker presents with high levels of intrapunitive hostility (self-criticism and delusional guilt) or depression, this is likely to positively affect the premature termination or completion of therapy for the child. The research disclosed that engaging the caretakers in family therapy is found to positively affect the rate of completion of therapy for the child (Venable & Thompson).

A study by Mohl, Martinez, Ticknor, and Appleby (1989) states the refusal of therapy is more likely to occur if the client has a family with little psychiatric history, overly elaborates the nature and intensity of their problems, has less of a history of alcohol abuse, is offered long-term individual therapy, or has a short wait for a screening appointment. They found that factors such as age, gender, diagnoses, severity, income, and education were not significant to therapy refusal.

Research Statement

There have been studies of gender differences in marriage and family therapy, but the authors have found no studies that examined the difference between the gender of the clients at initial contact and how many therapy sessions they attend. The authors were interested in examining if families or couples in which the male member of the family makes the initial contact to set up the first appoint will complete more therapy sessions than families or couples in which a female member makes the initial contact. The authors' hypothesis is that there will be a significant gender difference in the number of sessions attended. We believe that this research may pave the way for future research to look at what this difference is and what may be done on a personal and societal level to close the gender gap around initiating and completing therapy sessions.

Methodology
Sample

The sample utilized for this study were clients seen to therapy at the Clinical Services Center, which is a university based clinic located on the UW-Stout campus. The therapists at the clinic are second year Marriage and Family Therapy graduate students.

The clients' case files used were cases that closed in the year 2000. Every file from that year was included in the sample. The year 2000 was picked arbitrarily. The sample used in this study was one of convenience, as the files were available and it was a cost effective sampling strategy. To ensure

confidentiality, no identifying data from the sample files was collected. *Data Collection Procedures*

As mentioned above, the files that closed in 2000 at the Clinical Services Center were included in the sample. The data collected from the file included the gender of the person that made the initial contact to the Clinical Services Center. This information was determined by examining the gender of the person identified on the intake form. Next, data was collected on each file regarding the modality of therapy; that is, whether individual, couple, or family. This was determined by examining the payment sheet(s) located in the closed file, which indicated the modality of each session. If more then one modality was indicated on the payment sheet, the modality that was utilized the most was the one recorded. Finally, the last piece of data collected from the closed files was the number of sessions that were attended. This information could be found by examining the closing summary, where there is a space for total number of sessions or by counting the numbered progress notes completed for each therapy session.

The data collected was recorded on a data sheet that had three columns: one for modality, one for gender, and one for the number of sessions attended.

Data Analysis

The SPSS statistics program was utilized to analyze the data collected. The first attempt that was made to analyze the data yielded results that were not relevant to the research question. Due to these findings, only data from the modality of either couples or families was considered. The files that fit into the individual modality were removed from the sample.

The data entered in the SPSS was that of gender, either male or female, and the number of sessions attended for therapy. A Pearson Correlation Coefficient was done between the gender and number of sessions attended variables. Also, an independent sample t-test was done; which gave provided information regarding the mean and standard deviation with regards to the data entered.

The Pearson Correlation Coefficient was utilized as one of the data analysis methods so that the relationship could be examined between the two quantitative sets of scores, namely gender and number of sessions. The authors were interested in determining if there was a relationship between those two variables.

The t-test was utilized to determine if there was a true difference between the means of the two groups in this study or if the difference was created merely by chance error. The t-test will help determine whether to reject the null hypothesis and thus accept the hypothesis for this study.

Results

The Pearson's Correlation Coefficient was run utilizing the SPSS statistics program. The results of this analysis were not relevant to our study. The

independent t-test was also run with the SPSS statistics program. As seen in Table 1, the mean value when women initiated first contact was 7.9429 sessions attended when n=35. The mean value when men initiated first contact was 1.2857 sessions attended when n=7.

Table 1: Group Statistics

	GENDER	N	Mean	Std. Deviation	Std. Error Mean
Number of Sessions	FEMALE	35	7.9429	9.92307	1.67730
	MALE	7	1.2857	1.49603	.56544

Figure 1 shows that when men initiated first contact, the couples/families did not attend more then four sessions. When women initiated first contact, the couples/families attended a range from 0-45 sessions, with a median of four. Interestingly, almost a third of cases where women initiated contact and almost half of the cases where men initiated contact never followed up with any sessions at all.

Figure 1: Initiated Services vs. Amount of Sessions Attended
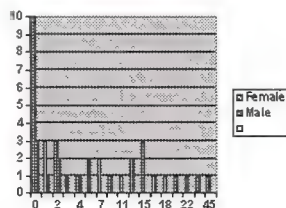
The independent t-test provides findings when equal variances are not assumed. As seen in Table 2, when equal variances are not assumed, there is a significant difference between the mean values at a p-value of .001 confidence level. When the equal variances are assumed, there is not a significant difference between the mean values. Upon examining the standard deviations and noticing that they are larger values then the means, the authors interpreted this to mean that the variances are not equal under a normal curve. The authors conclude that there is a significant difference between the means.

Table 2: Independent Samples Test

		t-test for Equality of Means			
			df	Sig.(2-tailed)	Mean Difference
Number of sessions	Equal variances assumed	754	0	.067	6.6571
	Equal variances not assumed	761	9.291	.001	6.6571

Given the results of this study, the authors' hypothesis is not supported. The findings actually challenge our initial thinking around this subject area; which will be discussed in the following sections.

Reliability and Validity

When looking at the validity of this research, one may contemplate whether or not the year 2000 is representative of other years. Perhaps this year may be different than others and the data from the year 2000 is skewed. In the year 2000 the authors acquired a very small number of males making the initial contact call. If there were a larger number of males making the initial contact call, the data may have shown different results. This concern could be addressed in future studies by comparing the results from this year to the results from other years.

The purpose of this study was to determine if there was a link between the gender of the person making the initial contact for therapy and the number of sessions completed. That the results of this study are significant at the .001 level, indicates that when the woman makes the first contact for therapy, couples and families complete significantly more sessions.

Factors that could have affected the validity of this study were: incorrect collection/entry of the data, choice of statistical test, and interpretation of the results. The authors believe that none of these factors negatively influenced the results.

Ethical Concerns

The authors are unaware of any ethical concerns for this research that have not already been covered. When clients come to the Clinical Services Center, they sign a consent form that states that their general information may be used for research purposes. Each one of the clients whose information was used in this research agreed and signed the consent form. Also, the information that we used for this research did not identify any specific individual.

Strengths and Limitations of the study

There are two major strengths of this research study. One of the strengths of this study was that almost all of the case files that were closed in the year 2000 were used in the research. Only four of the files were thrown out because of the ambiguity of which gender initially made the contact call with the clinic. We also look at a year's length of case files and examined each file that was closed in the year of 2000. This year's caseload totaled a high number of cases (n=94).

Another strength of this study is that it examines an area that has not been previously studied. This study has opened the door to a new way of looking at the relationship of gender and therapy and asks questions that when answered may yield important information for therapists.

There are also limitations to this study. There was little research for the authors to build upon as a foundation for the study. Specifically, there is little, if any, research that speaks specifically to gender differences and the number of sessions that are completed in therapy. Also, when collecting data

from files, the finding that some clients had attended individual and couple sessions and/or individual and family sessions required decisions to be made regarding how to count these files. In these instances the authors chose to record which type of session the participants attended most often. This also was a university clinic that had breaks in therapy that are not common for other clinics (holiday and semester breaks), and there also are changes in therapists during semester breaks and after graduation. This may attribute to people ending sessions earlier than they might if they had continuity in their therapists or sessions.

Clinical Implications

This study initially looked at gender and initial therapy contact and their interrelationship in completing more therapy sessions. The authors hypothesized that with a male making the initial contact, more therapy sessions would be completed. This hypothesis was not supported, however, this research has raised many unanswered questions.

The findings of this research indicate that when females make the initial contact, couples and families are much more likely to complete sessions than when males make the first contact. What is the rationale behind these findings? Perhaps when males decide that they must take action and seek help from outsiders the family/couple is in too much distress for them to benefit from therapy. Possibly, females have more power in their families and in family relationships than do males. Also, females may have more investment in maintaining help from others outside of the family, whereas males tend to view seeking help from outsiders as a weakness. It may also challenge men's ability to be a "man in control" if they are not able to control their children and have to go to therapy. If this is so, how can we as therapists, help males to feel more comfortable in being involved in therapy?

The findings also show that females are much more likely to make the initial contact call to engage in therapy. This may be because females feel as though they are more responsible for saving relationships. Further research may wish to explore the source of this pressure. Perhaps women are less satisfied and men more satisfied with their relationships, therefore women would be more apt to make the initial call because they are seeking change in the relationship.

The authors believe this study has opened a new area of research on gender and therapy. The hope is that others will follow in evaluating what these differences are, and why they exist, so therapists may be better able to understand these substantial differences between the genders.

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Modeling Oxygen Concentrations in Reaction Diffusion Systems

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Introduction

The goal of our research was to explore the mathematical foundations of reaction diffusion systems, specifically as they pertain to the diffusion of oxygen through a muscle fiber. The human body is moved by muscles, which account for over 40% of its weight. Muscles respond and adapt to the activities they are used for. If they are not used regularly, they weaken and atrophy sets in over time. Oxidative, or red, muscle fibers contain a large quantity of an oxygen-binding protein, called myoglobin. Myoglobin readily binds with gaseous oxygen to form oxymyoglobin. This uptake of oxygen into oxymyoglobin creates a continuous concentration gradient that pulls more oxygen into the fiber (Vander, 2001, p. 119). Once oxygen is in the cell it is used by mitochondria to produce energy, which powers the body. Exercise results in an increase in the amount of myoglobin in a muscle cell (or fiber). While oxygen does diffuse readily through a cellular membrane and into a muscle fiber on its own, oxymyoglobin increases the overall amount of oxygen available in the cell (Vander, 2001, p. 315). This binding of oxygen to myoglobin facilitates the diffusion process (Keener & Sneyd, 1998, p. 42).

In order to model such a process, we first need to develop a general three-dimensional model of diffusion where no reactions are occurring or are accounted for. Once this has been developed, it can then be applied in a one dimensional setting, without reactions, to explore the properties of the model. This model is then expanded to account for the addition of reactions which occur during diffusion, specifically the reaction between oxygen and myo-

is known as the gradient. The gradient, when applied to a function, produces a vector in the direction of the greatest rate of increase of the function. The magnitude of this vector is the rate of increase. Thus, equation (1) can be rewritten as:

$$\frac{d}{dt}\int_\Omega u \, dV = \int_\Omega f \, dV - \int_\Omega \nabla \cdot \vec{J} \, dV$$

Now that all of the integrals are volume integrals, the equation can be simplified to (Keener & Sneyd, 1998, p. 36):

$$\int_\Omega (\frac{\partial u}{\partial t} - f + \nabla \cdot \vec{J}) \, dV = 0$$

It is a well known fact of Real Analysis that if the integral of all sub-regions of a region has a value of zero, then the expression integrated must also be equal to zero. Therefore, the integral may now be dropped and the equation can be solved for the density change over time at a point. The resulting equation is sometimes called the "Unrefined Diffusion Equation" (Keener & Sneyd, 1998, p. 36).

$$\frac{\partial u}{\partial t} = f - \nabla \cdot \vec{J} \qquad (2)$$

While this equation does describe the process of diffusion, it can be further simplified by eliminating the quantity $\vec{J}$, flux density. Fick's Law (Keener & Sneyd, 1998, p. 36) provides an alternate model for flux. It states that, "During diffusion it is assumed that particles move in the direction of least density." This law allows the flux to be rewritten as $\vec{J} = -D\nabla u$, where D is a constant of proportionality called the diffusion coefficient (Keener & Sneyd, 1998, p. 37), and ∇u is a vector in the direction of largest density increase. D depends on the solute, temperature, and viscosity of the diffusing substance, among other factors. The negative sign causes the flux vector to point in the opposite direction, or towards the least density.

Ockham's Razor (Weisstein, 2003) is a principle of mathematics that states "If two models describe a system equally as well, choose the simpler of the two." Using this principle the diffusion coefficient is assumed to be constant. That is, it is assumed that the diffusion coefficient depends on neither time, nor location in the region in which diffusion is occurring. Using Fick's Law and Ockham's Razor, equation (2) can now be further refined to:

$$\frac{\partial u}{\partial t} = f - \nabla \cdot (-D\nabla u)$$

Combining the 's creates the Laplacian ( )

$$\frac{\partial u}{\partial t} = f + D\nabla^2 u \qquad (3)$$

This equation, called "The Refined Diffusion Equation", can be used to describe systems in which diffusion takes place.

Developing a Biological Ohm's Law

Ohm's law involves three different quantities: voltage (V), current (I), and resistance (R). Think of water flowing through a partially clogged pipe. The current is equivalent to the volume of water flowing through the pipe, the resistance is represented by the partial impermeability of a clog in the pipe which reduces the current (the total flow), and the voltage is the pressure difference on one side of the clog compared to the other. Ohm's law states that the relationship between these three terms is (Hewitt, 1998, pp. 400-401):

$$I = \frac{1}{R}V \quad (4)$$

A chemical counterpart of Ohm's Law can be developed using Fick's law and the xz diffusion equation (3). This equation can than be used to describe diffusion through a one-dimensional region of thickness L.

Let $c(x,t)$ denote the concentration of a chemical at a point x and time t that is diffusing across the region. This region has large chemical concentrations of a substance on the left and right hand sides. The concentration on the left side is denoted by $c(0, t) = cl$, and on the right side by $c(L, t) = cr$. Biologically, the length L could be, in theory, thought of as a one dimensional cell, and the chemical outside the cell could be oxygen.
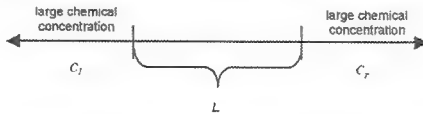
Assuming there is no local production of the chemical concentration of oxymyoglobin within the region, diffusion across the region can be modeled by the following one dimensional version of the diffusion equation.

$$\frac{\partial c}{\partial t} = D\nabla^2 c = D\frac{\partial^2 c}{\partial x^2} \quad (5)$$

This is the diffusion equation without the production component, using c in place of u, and using a one-dimensional version of the Laplacian. The one-dimensional Laplacian is written as:

$$\nabla^2 = \frac{\partial^2}{\partial x^2}$$

By assuming that the diffusion process across the region is at a steady rate, the subsequent change in concentration at a point over time will be zero. Mathematically this is written as:

$$\frac{\partial c}{\partial t} = 0$$

Combining this with equation (5) produces:

$$D\frac{\partial^2 c}{\partial x^2} = 0 \quad (6)$$

Dividing equation (6) by the diffusion coefficient (D) (Keener & Sneyd, 1998, p. 37) and then integrating both sides of (6) twice with respect to x reveals a

linear model for the concentration with respect to x. Both a and b are constants produced by the integration. This linear model is written as:

$$c(x) = ax + b \quad (7)$$ (7)

Using the boundary conditions $c(0) = c_l$ and $c(L) = c_r$ in combination with equation (7) shows that: $\quad a = \dfrac{c_r - c_l}{L} \quad$ and $\quad b = c_l$

Substituting the values of a and b into equation (7) results in:

$$c(x) = c_l + (c_r - c_l)\frac{x}{L} \quad (8)$$

Differentiating equation (8) with respect to x yields:

$$\frac{\partial c}{\partial x} = \frac{c_r - c_l}{L}$$

Utilizing Fick's Law ($J = -D\nabla c$), where J is recognized as a scalar now instead of a vector due to the dimension change, and the fact that

$$\nabla c = \frac{\partial c}{\partial x}$$

the equation for flux of the chemical across the membrane can be written as:

$$J = \frac{D}{L}(c_l - c_r) \quad (9)$$

　　　　Upon closer inspection a relationship can be seen between equation (4) and equation (9). J, the flux, corresponds to I, the current. D/L, the permeability of the region, corresponds to the 1/R, the conductance. And $c_l - c_r$, the concentration difference, corresponds to V, the voltage. Equation (9) is referred to as the biological equivalent of Ohm's Law. It describes the simplest diffusion scenario, using a one-dimensional model with no chemical reactions, and therefore no sources or sinks for the oxygen exist, other than the concentration gradient of oxygen. (Keener & Sneyd, 1998, p. 38).
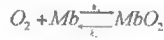
Reaction-Diffusion Systems

　　　　The Ohm's Law diffusion model can be expanded to include the possibility of reactions among the diffusing particles. When diffusing particles are involved in enzymatic reactions, the system is called a "reaction-diffusion system". An example of such a system occurs when oxygen reacts with and is bound to myoglobin in muscle fibers. It is then transported as oxymyoglobin, causing the overall flow of oxygen to be amplified above that of free oxygen within the system (Keener & Sneyd, 1998, p. 39).

　　　　A one-dimensional slab reactor can be used to model this mathematically. The model of oxygen flux within a slab (or reservoir) reactor can be constructed using the diffusion equation. Biologically, this slab can be thought of as a muscle fiber.

large chemical reservoir of O_2　　　　slab　　　　large chemical reservoir of O_2

$x = 0$　　　　$0 < x < L$　　　　$x = L$
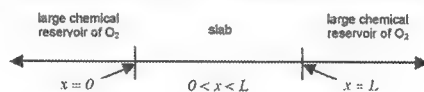
Developing a Model for Total Oxygen Flux

$$O_2 + Mb \underset{k_-}{\overset{k_+}{\rightleftharpoons}} MbO_2$$

The slab contains myoglobin, which reacts with the oxygen to form oxymyoglobin. Myoglobin can not leave the slab in unbound or bound form. The chemical reaction above states that oxygen and myoglobin are bound to form oxymyoglobin at rate k+, and that oxymyoglobin decomposes into oxygen and myoglobin at rate k-.

The diffusion equation (3) can be used to model the behavior of the concentrations of oxygen (s), myoglobin (e), and oxymyoglobin (c). The rate of change in oxygen with respect to time is given by:

$$\frac{\partial s}{\partial t} = D_s \frac{\partial^2 s}{\partial x^2} - f \quad (10)$$

The rate of change in myoglobin with respect to time is given by:

$$\frac{\partial e}{\partial t} = D_e \frac{\partial^2 e}{\partial x^2} - f \quad (11)$$

And the rate of change in oxymyoglobin with respect to time is given by (Keener & Sneyd, 1998, pp. 39):

$$\frac{\partial c}{\partial t} = D_c \frac{\partial^2 c}{\partial x^2} + f \quad (12)$$

The production component of the diffusion equation (f), is modeled as the rate of uptake of oxygen into oxymyoglobin, and is given by . $f = k_+ s e - k_- c$ In Layman's terms it reads "The uptake of oxygen into oxymyoglobin is equal to the forward rate constant multiplied by the concentrations of oxygen and myoglobin, minus the reverse rate constant multiplied by the concentration of oxymyoglobin." This expression for f is derived using the compartmental analysis diagram shown in the figure below.
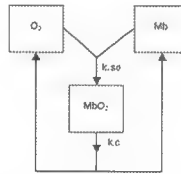
The system can be further simplified by making two physical assumptions and one observation. The first assumption is that $D_e \approx D_c$. As myoglobin and oxymyoglobin are nearly identical in molecular weight and structure, this is a reasonable assumption to make. Second, at the boundaries of the slab, x = 0 and x = L , it is assumed that the concentrations of oxymyoglobin and myoglobin will gradually taper off, rather than instantaneously dropping off at the boundary. Mathematically this means that

$$\frac{\partial e}{\partial x} = \frac{\partial c}{\partial x} = 0$$

as x = 0 and x = L. Although this is not used in the model presented here, it is a useful assumption that could be used as an initial condition to solve the system of equations that models diffusion.

Since the total amount of myoglobin in the slab reactor is conserved, it can be seen that the sum of the free myoglobin plus the bound myoglobin must equal the total myoglobin present before the reactions began. The total myoglobin is denoted by e0. Symbolically this can be written as $e + c = e_0$. Since e depends on c, the diffusion equation for myoglobin, (11), can be eliminated from the current system, leaving only equations (10) and (12).

Assuming the system is at quasi-steady state, which occurs when the change in the rates of formation and breakdown of oxymyoglobin are the same. From this it follows that the oxygen coming in from the blood is equal to the amount of oxygen being consumed in the mitochondria. Thus, the net change in the concentrations of all the chemicals involved will be zero. The equation that describes the concentrations of oxygen and oxymyoglobin at quasi-steady state is:

$$\frac{\partial s}{\partial t} + \frac{\partial c}{\partial t} = 0 \quad (13)$$

Substituting equations (10) and (12) into equation (13), yields:

$$0 = D_s \frac{\partial^2 s}{\partial x^2} + D_c \frac{\partial^2 c}{\partial x^2}$$

Integrating this new equation with respect to position(x) gives:

$$D_s \frac{\partial s}{\partial x} + D_c \frac{\partial c}{\partial x} = a$$

where a is a constant (Keener & Sneyd, 1998, pp. 39). Using the model for flux given by Fick's law, an equation for the total flux of oxygen at any point within the slab can be written as:

$$J = -\{ D_s \frac{\partial s}{\partial x} + D_c \frac{\partial c}{\partial x} \}$$

This equation models the flux at only one point, but an equation for the total flux in the slab can be obtained by integrating J over the entire slab with respect to position. This equation is written as:

$$\Im = \int_0^L -(D_s \frac{\partial s}{\partial x} + D_c \frac{\partial c}{\partial x}) dx$$

After being evaluated, this yields an equation that governs oxygen flux in the slab.

$$\Im = -D_s(s_0 - s_L) - D_c(c_0 - c_L) \quad (14)$$

The quantities s_0 and s_L, the concentrations of oxygen at the boundaries of the slab, are known; but c_0 and c_L, the concentrations of oxymyoglobin at slab boundaries, are not. The system of equations:

$$D_s \frac{\partial^2 s}{\partial x^2} - f = 0 \quad \text{and} \quad D_c \frac{\partial^2 c}{\partial x^2} + f = 0.$$

can now be used along with the process of nondimensionalization to determine

the values of c_0 and c_L. Essentially, nondimensionalization is the choosing of a typical or characteristic value for each variable, and then relating this value to the actual value of the variable. The new variables will no longer have physical labels, such as meters or grams, associated with them (Keener & Sneyd, 1998, p. 26).

The dimensionless variable for the "scaled substrate" is:

$$\sigma = \frac{k_+}{k_-} s$$

for the "scaled complex":

$$u = \frac{c}{e_0}$$

and for the "rescaled spatial variable":

$$x = Ly.$$

Substituting these variables into the system, the following equation is found:

$$\varepsilon_1 \sigma_{yy} = \sigma(1-u) - u = -\varepsilon_2 u_{yy}$$

where

$$\varepsilon_1 = \frac{D_s}{e_0 k_+ L^2}, \quad \text{and} \quad \varepsilon_2 = \frac{D_c}{k_- L^2}.$$

Experimental data (Keener & Sneyd, 1998, p. 40) suggests that

$$\varepsilon_1 \approx 1.5 * 10^{-7} \quad \text{and} \quad \varepsilon_2 \approx 8.2 * 10^{-5}.$$

This data suggests that it is reasonable to approximate the value of $E2$ and $E1$ with zero. Setting the epsilon values to zero, and solving for u yields:

$$u = \frac{\sigma}{\sigma + 1}$$

Using back substitution for σ produces:

$$u = \frac{\sigma}{\sigma + 1} = \frac{\left(\frac{k_+}{k_-}\right)s}{\left(\frac{k_+}{k_-}\right)s + 1} = \frac{c}{e_0}$$

Further simplification yields:

$$\frac{c}{e_0} = \frac{s}{s + \frac{k_-}{k_+}}$$

Note that in this last equation that both c and s depend on position, that is $c = c(x)$ and $s = s(x)$. Using the boundary conditions $c(0) = c_0$ and $c(L) = c_L$, the values of c_0 and c_L can be calculated. Using these conditions produces the equations:

$$c_0 = \frac{e_0 s_0}{s_0 + K} \quad \text{and} \quad c_L = \frac{e_0 s_L}{s_L + K}$$

where:

$$K = \frac{k_-}{k_+}$$

Substituting the values of c_L and c_0 into (14) generates:

$$\Im = \frac{D_s}{L}(s_0 - s_L) + \frac{D_c}{L}e_0\left(\frac{s_0}{K+s_0} - \frac{s_L}{K+s_L}\right)$$

When reduced, this yields:

$$\Im = \frac{D_s}{L}(1 + \mu\rho)(s_0 - s_L) \quad (15)$$

Note: In equation (15) the following two substitutions have been made:

$$\Im = \frac{D_s}{L}(1 + \mu\rho)(s_0 - s_L)$$

This final equation, (15), mathematically describes the total flux of oxygen within the slab at quasi steady state. Recall that equation (9) is a model of flux without reactions. If no myoglobin is present, $e_0 = 0$, then equation (15) becomes a replica of equation (9).

Modeling Muscle Respiration

"Muscle respiration" refers to the utilization of the available oxygen to produce energy for the cell. Adequate circulation of oxygenated blood and the use of the oxygen storage pigment, myoglobin, enhances the muscle fiber's ability to produce energy (ATP) aerobically (Vander, Sherman & Luciano, 2001, p. 464). The process of oxygen diffusion within the cell can be modeled mathematically using a three-dimensional cylindrical model and the diffusion equation.

To model any particular point in time on such a model, the coordinates (r, _, z) are used. For this point, r denotes the radius, _ denotes the rotation about the central axis, and z denotes the height within the cylinder.
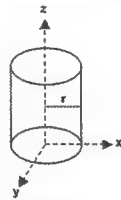
A Cylinderical Model

In order to use a cylindrical model to mathematically represent a muscle fiber and keep the model simple, two assumptions must be made. First, the oxygen concentration is assumed to be fixed on the outside of the "fiber". Second, at steady state the oxygen (s) and oxymyoglobin (c) will be distributed radially and symmetrically about the z axis. Visually, this last assumption about the cylindrical model can be thought of as similar to the symmetry of the rings in a tree. The concentration of oxygen at any two points in the model must be the same if they have the same radius value, no matter what the angle or height; just as rings in a tree are essentially the same as one travels around or up and down on a particular ring. Thus, in effect, the concentration of substrate (oxygen) in the model only depends on r, rather than on r, _, and z.

Recalling the diffusion equation, (3), where u represents the concentration at a particular point in time:

$$\frac{\partial u}{\partial t} = f + D\nabla^2 u$$

and the Laplacian of u is given by: $\nabla^2 u = \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2}$

Combining the cylindrical coordinates (r, _, z) with the Laplacian equation and using the chain rule yields:

$$\nabla^2 = \frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2}{\partial\theta^2} + \frac{\partial^2}{\partial z^2}$$

Condensed, using the assumption of radial symmetry which states that the values of _ and z can be discarded since they play no role in the change in concentration, the Laplacian for this scenario can now be rewritten as:

$$\nabla^2 = \frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial}{\partial r}\right) \quad (16)$$

Modeling Muscle Respiration

Temporarily ignoring oxygen consumption by the cells, in order to create a simpler model, the rate of change of oxygen with respect to time in the cylindrical model can be modeled by the diffusion equation and be written as:

$$\frac{\partial s}{\partial t} = D_s\nabla^2 s - f \quad (17)$$

In English, this states that "the rate of change of oxygen with respect to time is equal to the diffusion coefficient of the oxygen multiplied by the Laplacian of the oxygen concentration minus the oxygen concentration produced by the uptake of oxygen into oxymyoglobin."

Similarly, in the absence of oxygen consumption, the rate of change of oxymyoglobin with respect to time in the cylindrical model can be written mathematically as:

$$\frac{\partial c}{\partial t} = D_c\nabla^2 c + f \quad (18)$$

This equation states that the rate of change of oxymyoglobin with respect to time is equal to the diffusion coefficient of the oxymyoglobin multiplied by the Laplacian of the oxymyoglobin concentration plus the oxymyoglobin concentration produced by the uptake of oxygen into oxymyoglobin.

Oxygen and Oxymyoglobin in Steady State

At steady state, the rate of change of the oxygen concentration is assumed to be 0. Replacing the partial derivative in equation (17) with 0, and expanding the Laplacian produces:

$$0 = \frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial s}{\partial r}\right) - f - g \quad (19)$$

where f represents the uptake of oxygen into oxymyoglobin, and g represents the oxygen consumption by muscle cells, which was ignored earlier. This new equation accounts for the consumption of oxygen at steady state (Keener & Sneyd, 1998, pp. 42).

Similarly, at steady state, the rate of change of the oxymyoglobin concentration is assumed to be 0. Replacing the partial derivative in equation (18) with 0, and expanding the Laplacian yields:

$$0 = D_c \frac{1}{r} \frac{\partial}{\partial r}\left(r \frac{\partial c}{\partial r}\right) + f \qquad (20)$$

This gives an equation that governs the oxymyoglobin concentration (Keener & Sneyd, 1998, pp. 42).

Boundary Conditions

Equations (19) and (20) provide a system of equations with which to model the concentrations of oxygen and oxymyoglobin within a muscle fiber. To use this system we must have some boundary conditions. First, the oxygen concentration at the outermost edge of the cylindrical model (or muscle fiber) is assumed constant and is represented by the sa, hence the rate of change of oxymyoglobin at this boundary (where r = a) is 0. Second, at the center of the cylindrical model, the rate of change of oxygen and oxymyoglobin is assumed to be 0. These general assumptions can be modeled via a simple graph:

Steady State Concentrations of Oxygen and Oxymyoglobin

radius(r)
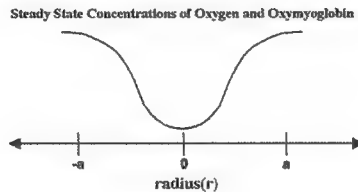
Conclusion

Through the use of the mathematical models described above, the boundary conditions given, and asymptotic methods (not discussed here), the metabolic process of oxygen consumption in muscle respiration can be modeled. These tools allow us to analyze the concentration of oxygen in a muscle fiber and to predict the likelihood of oxygen debt based on the amount of myoglobin present.

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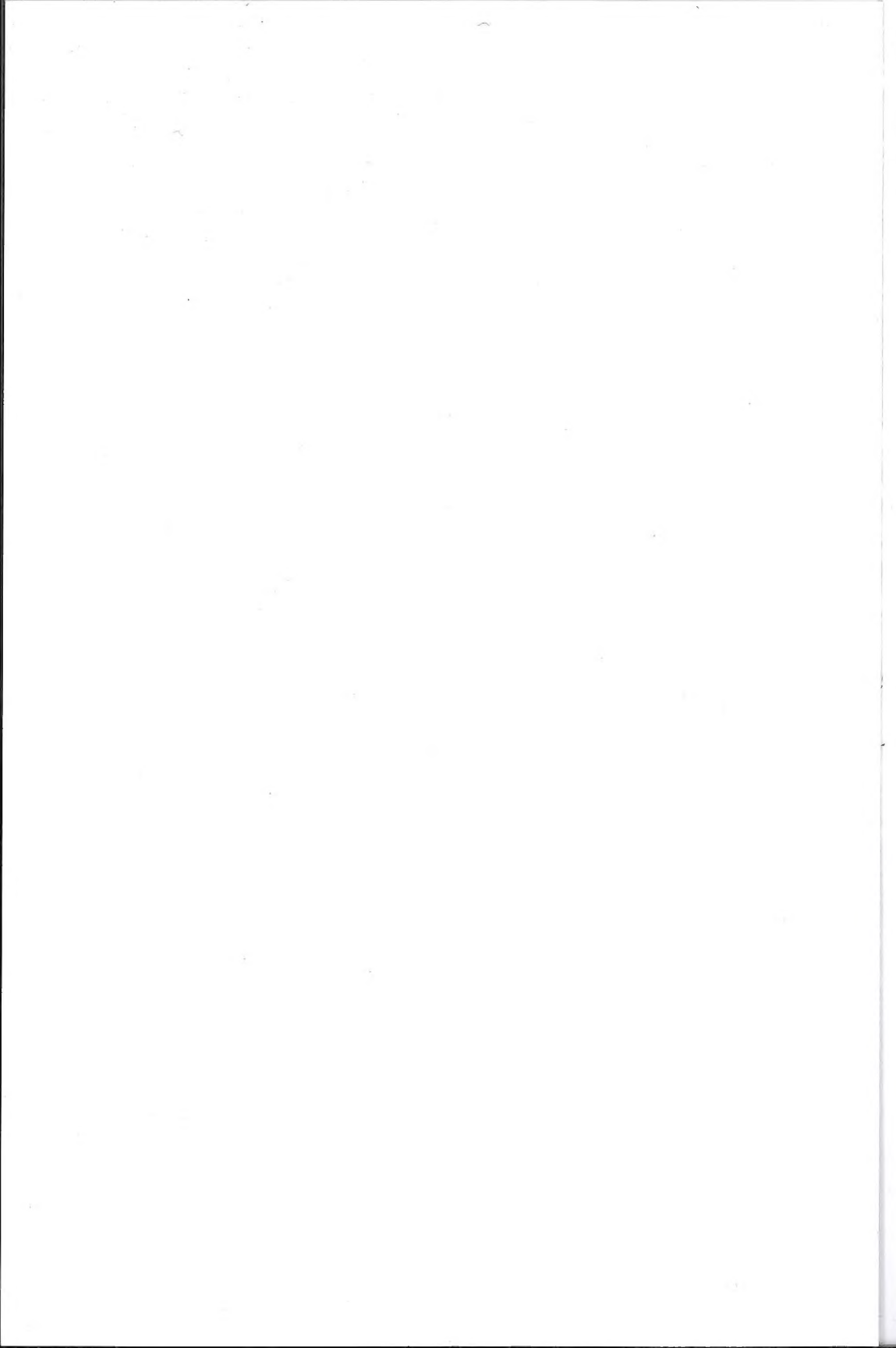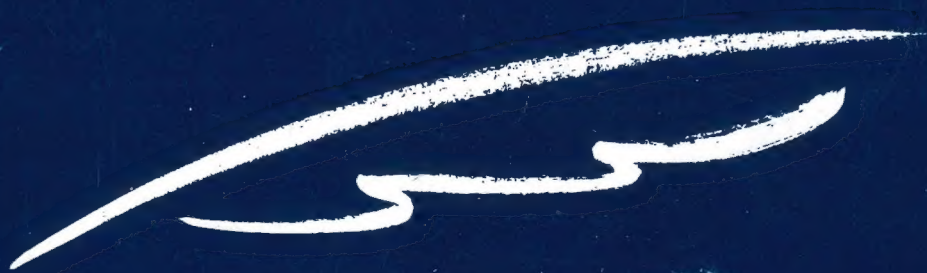Article Total Score   _____/100

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